Identifying Hazards

The risk assessment shall include an] overview of the type … of all natural hazards that can affect the State…

Disaster History

The initial list of identified hazards was completed by the UPDMPC in conjunction with the State Hazard Mitigation Team. Several associations of government added hazards to the list based on input from local jurisdictions. To identify hazard the UPDMPC pursued the following:

Past Presidential Disaster Declarations

Utah's past presidential disaster declarations were examined. After being the first state in the nation to receive a presidential Utah has had very few declarations, one of lowest in the country. What follows is a brief history and explanation of the presidential declarations:

<u>1983 Statewide flooding</u>

The floods of April 10-June 25, 1983, affected 22 counties, or more than three-fourths of the State. On April 10, a landslide caused by precipitation dammed the Spanish Fork River, which then inundated the community of Thistle. The landslide, which resulted in damage totals of about $200 million and a Presidential disaster declaration, was the most costly geologic phenomenon in Utah's history and the most costly landslide in US history (Utah Division of Comprehensive Emergency Management, 1985, p. 40).

Rapid melting of the snowpack with maximum-of-record water content for June 1 (U.S. Soil Conservation Service. 1983) resulted in the largest and most widespread flooding in the State's history; peak discharges had recurrence intervals that exceeded 100 years on several streams. New discharge records were set on many others, such as Chalk Creek at Coalville. On June 23, the Delta-Melville-Abraham-Deseret Dam on the Sevier River near Delta failed as a result of the flooding on June 23, 1983, and released 16,000 acre-feet of water down the river. Two bridges were washed away, and the town of Deseret was inundated by as much as 5 feet of water (Utah Division of Comprehensive Emergency Management, 1985, p. 41).

Overall damage from the April 10- June 25, 1983, floods totaled $621 million (Stephens, 1984, p. 20-36). No deaths were attributed to the floods.

<u>1984 Statewide Flooding</u>

The May 24, 1984, flood on the Beaver River near Beaver and other flooding during the April 17- June 20,1984, floods caused damage second in magnitude only to damage in 1983. The major cause of the flooding was much greater than average snowpack and greater than normal precipitation that continued throughout the spring. Peak discharges exceeded those in 1983 at some sites on the White, Bear, Jordan, and Beaver Rivers. Owing to severe flooding in 12 counties, a disaster was declared by the President. On

May 14, rainfall caused a mudslide near the coal-mining town of Clearcreek that killed one person and injured another. The direct impact on people was considerably less in 1984 compared to 1983 because of mitigation measures implemented during the previous year. Total damage for floods and landslides was estimated to be $41 million (Utah Division of Comprehensive Emergency Management, 1985, p. 15).

1989 Quail Creek Dam Failure

- Quail Creek Dike and facilities lost
- 30 homes, 58 apartments, and nine businesses flooded
- Loss to agriculture and livestock
- Impacts to public facilities, roads, bridges, and golf courses
- Reduce in population of Wound Fin Minnow an endangered species
- Public assistance $1,133,721 wit a federal share of $850,294

1999 Salt Lake City Tornado

- 1 death
- 80 injuries
- 300 buildings or houses were damaged
- 34 homes left uninhabitable
- 500 trees were destroyed
- A portion of Memory Grows was completely destroyed
- Total damage estimates $170 million.
- Federal assistance

Mitigation plans completed by the Association of Governments in conjunction with local jurisdictions where reviewed to see if any hazards were identified at the local level which warranted review at the state level. All seven AOG had a sit down meeting with each jurisdictions mayor or lead planner to address a survey put together by the AOG. One of the questions in this survey was to list vulnerable hazards. Radon and infestation were both identified in the Five County Association of Government plan.

Previous State Natural Hazard Mitigation Plans were reviewed to see if perceived vulnerability to hazards had changed over the years and if so how. This study of almost 20 years of plans, showed vulnerability had changed over time but the hazards had not. Following flooding in 1983 and 1984 large investments were made in mitigation. This investment reduced the vulnerability to similar flood events in some of the larger counties, yet increased population and the conversion of agricultural land to residential development still makes flooding despite the mitigation, a hazard in Utah.

Borrowing a principle from Geology " the past is the key to the future" it is important to understand past events or a states disaster history in order to foresee future problems. A chronological history was assembled for each hazard, which can occur in Utah. This work was primarily conducted by each AOG with input from the U.S. Army Corps of Engineers and DES. Disaster history's were compiled from numerous sources including but not limited to: Flood Insurance Studies, newspaper articles, the University of Utah

Seismograph Stations, interviews, surveys, past mitigation plans, libraries, microfilm, and the Utah Historical Society.

Several recent and not so recent studies, played into identifying hazards. These studies included hydrologic, meteorological, drought, and new research on seismisity, particularly along the Wasatch Front. Many of these studies have shed new light on past events; in some cases we have found, there is a higher risk then previously thought. For example a seismic study being headed by Sue Olig, on the Wasatch Fault, contain preliminary results indicating a shorter recurrence interval for events on the Wasatch Fault.

Figure I-1 Large trench dug in Mapleton as part of the earthquake recurrence interval study. Photo Bob Carey

As a result of this study the state plan addressed the following major natural hazards:

- Earthquake, including association hazards of fault rupture, liquefaction, etc.
- Flood
- Landslide, including debris flow
- Dam Failure
- Wildfires
- Drought
- Severe Weather includes winter storm, high wind, avalanche, and tornado.

Based on the hazard history and profiles of the aforementioned hazards, the recurrence interval and hazard frequency were determined (see Table I-1). The recurrence interval was calculated by dividing the number of years observed for each hazard by the number of events reported. For example, there had been 116 documented tornadoes during a 54-year period. This information provides a recurrence interval of 54/116 or 0.47. The hazard frequency was calculated by dividing the number of events observed by the number of years. For example, 53 wildfires larger than 5000 acres divided by 17 years indicates that an average of 3.12 large wildfires occur in Utah in any given year.

Table I-1 Utah Hazard Recurrence and Frequency

Hazard	Number of Events	Years in Record	Recurrence Interval (years)	Hazard Frequency and Probability/Year
Droughts*	61	109	1.787	56%
Earthquakes**	31	128	4.129	2.4%
Landslides	N/A	N/A	N/A	N/A
Floods***	14	120	8.57	12%
Tornadoes (all)	116	54	0.47	215%
Avalanches (fatalities)	70	45	0.643	156%
Wildfires	53	17	0.320	312%

(>5000 acres)				
Thunderstorms and Lightning (fatalities)	57	54	0.947	106%

*PDSI, single year events counted.
** Magnitude 5.0 or larger
*** Only large flooding events
Landslide recurrence intervals cannot be predicted because landslides often have recurrent movement with the same landslides moving each year depending on climate.

Table I-2 Utah Disaster Loss Data 1970 through 2004

Event	Injuries	Fatalities	Property Damage*	Crop Damage*
Hail	86.01	0	$2,262,500.01	$2,402,300.01
Fog	18	4	$200,000	0
Flooding	32	15.01	$82,433,999.98	$50,761,7000.04
Avalanche	12.01**	9**	$100,000.02	0
Lightning	20**	9**	$2,289,700.03	0
Tornado	92	1	$173,015,500	$507,700
Severe Snow	47.95	8.96	$5,479,000.11	$206,800
Winterweather	677.11	40.71	$62,247,001.18	$6,585,099.79
Wind	133	10.96	$54,419,633.56	$1,724,300.97
Total	1,118.08	99.64	$382,467,334.89	$62,227,900.81

Source: www.sheldus.org
* Totals are not inflation adjusted
** More accurate data exist

Table I-3 County Disaster Losses 1970 through 2004

County	Injuries	Fatalities	Property Damage*	Crop Damage*
Beaver	24.74	1.02	$4,533,485.56	$2,423,779.31
Box Elder	79.21	5.39	$10,716,346.17	$1,791,634.75
Cache	49.81	6.87	$10,165,751.11	$2,972,527.75
Carbon	23.91	1.81	$4,860,064.07	$2,436,085.16
Daggett	7.40	0.61	$1,803,129.48	$22,117.02
Davis	59.52	5.19	$16,069,948.87	$3,096,251.32
Duchesne	21.91	2.67	$5,142,583.22	$2,425,404.65
Emery	27.04	2.43	$3,241,851.90	$150,684.07
Garfield	15.90	2.58	$4,622,599.39	$2,426,136.45
Grand	7.56	3.58	$716,188.80	$23,058.78
Iron	41.18	1.52	$5,450,598.68	$3,064,261.36
Juab				

	39.71	4.98	$5,252,611.65	$2,811,389.70
Kane	14.77	2.37	$2,620,182.10	$153,884.07
Millard	30.22	1.25	$4,659,647.95	$2,796,728.03
Morgan	31.63	3.30	$5,584,571.59	$2,793,606.83
Piute	14.37	1.37	$2,032,318.46	$63,517.41
Rich	22.48	1.44	$5,346,310.39	$2,403,841.48
Salt Lake	209.40	15.26	$194,940,180.66	$4,050,253.80
San Juan	8.94	4.64	$4,786,515.09	$2,794,491.97
Sanpete	27.99	4.69	$6,121,009.13	$3,344,824.35
Sevier	14.37	1.58	$4,467,144.84	$2,849,285.17
Summit	34.37	4.76	$5,681,517.10	$2,434,604.65
Tooele	52.83	4.96	$13,350,595.71	$2,473,369.60
Uintah	11.44	0.61	$5,236,755.71	$2,404,677.82
Utah	87.75	5.43	$12,214,804.03	$3,959,320.46
Wasatch	32.16	2.76	$2,542,502.25	$40,952.27
Washington	30.21	3.37	$18,470,002.77	$2,893,836.45
Wayne	15.96	0.43	$2,076,048.11	$49,184.07
Weber	81.30	2.77	$19,762,070.10	$3,078,192.06

Source: www.sheldus.org
* Totals are not inflation adjusted

The hazards were then ranked as low, medium, or high priority (see Table I-4) based on the frequency of past occurrences, the magnitude of the impact of past events, the potential for future impact, perception of threat level, and potential to caused significant damage.

Table I-4 Utah Hazards Ranked

High Priority	Medium Priority	Low Priority
Wildfires/Urban Interface	Droughts	Volcanoes
Floods	Severe Weather	Problem Soils
Earthquakes	Landslides	Radon Gas
	Dam Failure	

Other Hazards

The identified hazards for which mitigation strategies have been outlined in the following chapters are by no means the only natural hazards, which could affect the State. Other natural hazards could possibly occur, such as volcanic activity, although the probability of such an occurrence is so slight the, UPDMPC did not fully consider them.

Man Made Hazards

In addition to the natural hazard, the state exhibits risk to a number of technological or man-made hazard, these include but are not limited to:

- Hazardous materials incidents
- Disruption of energy systems, and petroleum fuel pipelines
- Terrorism
- Civil unrest
- Disruption of transportation systems
- Weapons of Mass Destructions (WMD): conventional explosives, nuclear, biological, or chemical

Some of these hazards, such as hazardous materials incidents and disruption of energy, can occur as a secondary effect of a natural hazard event. For example a large earthquake can cause significant disruption to infrastructure systems and cause numerous hazardous materials incidents. Mitigations strategies described in this plan address a reduction in the effects of natural hazards, yet as described above regardless of the cause the emplace mitigation can still provides benefit. It is expected future revisions to the State Natural Hazard Mitigation Plan will include additional hazards such as technological and man made hazards, until at some point an all inclusive mitigation plan is created.

Problem Soils

Problem soils and rock constitute a widespread geologic hazard in Utah, covering approximately 18 to 20 percent of the state, and underlie many urbanized areas. The nine types of problem soil and rock in Utah are:

- Expansive Soil
- Collapsible Soil
- Limestone and Karst Terrain
- Gypsiferous Soil
- Soil Subject to Piping
- Dunes
- Peat
- Mine Subsidence
- Sodium Sulfate

Problem soils are not fully addressed in this mitigation plan because:

- Although problem soils cover a large geographic extent, within the State, they seldom cause wild spread damage.
- Most problems associated with problem soils are well understood and easily and often mitigated for during construction.

Examples of problems soil mitigation can be seen throughout southern Utah, roads have been elevated on top of imported fill; this process adds initial cost but must be done to prevent road failures due to expansive soils.

Radon Gas

Radon, a naturally occurring, odorless, tasteless, radioactive gas produced by the breakdown of uranium in rock and soil. It is harmlessly dispersed in outdoor air, but when trapped in buildings, can be harmful, especially at elevated levels. Radon was not considered a hazard because radon only results in an increased likely hood of developing cancer, although not everyone who is exposed to radon develops cancer. Chances increase with increasing levels of radon and length of exposure. Additionally the amount of time between exposure and onset of the disease is usually many years.

Radon is the second leading cause of lung cancer, after smoking. The U.S. Environmental Protection Agency and the Surgeon General have recommended that all residences (except those above the second floor) be tested for radon. An estimated 14,000 deaths each year can be attributed to excessive radon exposure. Radon does not cause any short-term health effects, such as shortness of breath, coughing, headaches or fever.

Radon comes from the soil surrounding and beneath the house, especially soil that contains uranium. It typically moves up through the soil into the air above and then into your home through cracks in foundations and walls, openings around sump pumps and drains, and construction joints. The highest concentrations of radon can be found in the lowest levels of the home.

Radon may also be present in well water and can be released into the air in your home when water is used for showering and other household uses. The risk of radon entering homes through water is small compared with that of radon entering through the soil. Usually, radon is not a problem with large community water suppliers, but private wells can contain high levels.

The inclusion of radon in this mitigation plan was demeaned unnecessary for the following reasons:

- Radon is a wide spread hazard which caused no property damage the only damage comes from loss of life.
- Radon would most likely not constitute a Presidential Declaration
- Easily mitigated, once identified

Radon reduction measures can vary with radon levels, but most often the measures cost no more than having a new hot water heater installed or having the house painted. The cost of a contractor fixing a home generally ranges from $500 to $2500, depending on the characteristics of the house and choice of radon reduction methods. For a list of EPA approved contractors in Utah, contact: Utah Safety Council; 5263 South 300 West, Suite 201 Salt Lake City, Utah 84107

Utah Geologic Survey has done a large amount of research on radon gas and has several publications available at the Division of Natural Resources book store or through the UGS website.

Volcanoes

Volcanoes are created when internal forces in the Earth, cause heated, melted rock (magma) to rise to the surface. First collecting in magma chambers, some of the magma eventually pushes upward through cracks (vents) to the Earth's surface. As the magma reaches the surface, it loses some of its gases and turns into lava. Volcanoes are created by the release and build-up of lava and other materials. Volcanoes have varied shapes and sizes, but are divided into three main kinds depending on the type of material that reaches the surface and the type of eruption that ensues. Utah has all three types.

1. ***Composite or Stratovolcanoes***

Composite volcanoes (stratovolcanoes) develop from repeated explosive and non-explosive eruptions of tephra (airborne lava fragments that can range in size from tiny particles of ash to house-size boulders) and lava that build up layer by layer. These volcanoes are the largest and form symmetrical cones with steep sides. Some composite volcanoes in Utah are in the Tushar Mountains (Mount Belknap, for example) in Piute County. Now extinct, they are too old (between 32 and 22 million years) to maintain the classic volcanic shape of their modern-day counterparts, such as Mount Hood and Mount St. Helens in the Cascade Range along the northwestern coast of the United States.

2. ***Shield Volcanoes***

Shield volcanoes form from "gentle" or non-explosive eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The low-profile shape resembles a warrior's shield. In Utah a good example is the one-million-year-old Fumarole Butte in Juab County. Currently active volcanoes of this type are found in the Hawaiian Islands.

3. ***Cinder Cones***

Cinder cones build from lava that is blown violently into the air and breaks into fragments. As the lava pieces fall back to the ground, they cool and harden into cinders (lava fragments about 1/2 inch in diameter) that pile up around the volcano's vent. Cinder cones are the smallest volcanoes and are cone-shaped. Cinder cones are found in many areas of Utah including Millard, Iron,

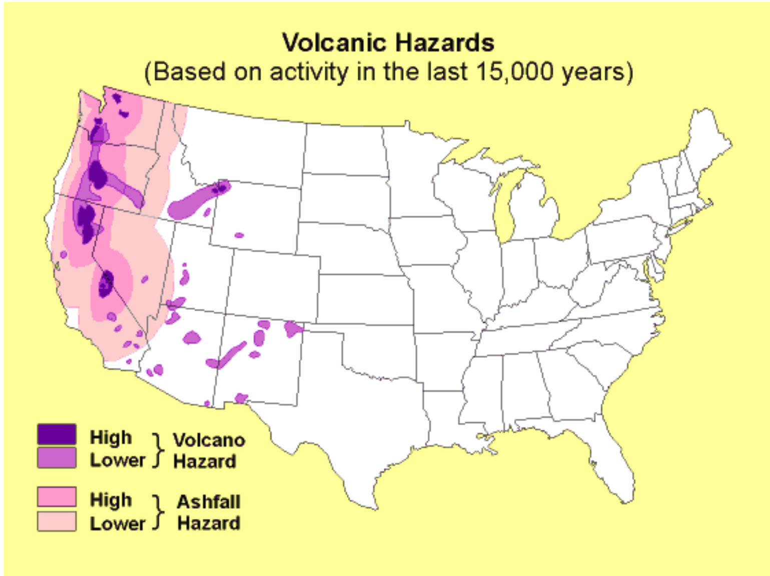


Figure I-2 US Volcanic Hazards
Source: http://www.usgs.gov/themes/map2.html

Garfield, Kane, and Washington Counties, and they vary in age. The youngest, only about 600 years old, are in the Black Rock Desert in Millard County.

There have been several major volcanic eruptions worldwide during the past 25 years. Among these were the eruption in 1980 of Mt. St. Helens in Washington State followed by the 1982 eruption of El Chichón in Mexico, the 1990 eruption of Mt. Pinatubo in the Philippines, and the 1995 eruption of the Soufriere Hills Volcano in Montserrat all generated unprecedented awareness to the potential calamitous effect of volcanic hazards. Fortunately, these events have not had any significant effect on residents of Utah.

Over 270,000 human fatalities have resulted worldwide from volcanic activity during the past 500 years. Information from the Utah Geological Survey indicates that while most of the deaths world-wide have been related to the eruptions of high-silica alkali composition volcanics, fatalities and property damage can result from basaltic and rhyolitic flows, plugs and dome, features that are typical of volcanism throughout Utah, particularly southwestern Utah.

When discussing inclusion of volcanic hazards into this mitigation plans several problems arose. Because of the intermittent nature of volcanic eruptions and lengthy recurrence intervals, people tend to minimize volcanic hazards as a threat to property and lives, which is understandable. While Geomorphically fresh features and textures, geothermal anomalies, and recent eruptive histories present convincing arguments for the continuation of volcanic events in Utah. This mitigation plan does not address volcanic risk for the reason that:

- The only current hazard would strictly be from local, small cinder cone basaltic eruptions.
- Rather than local events, remote eruptive centers present Utah's most imminent and potentially damaging volcanic hazard. Areas east of Mt. St. Helens were the recipients of ash fallout.
- Long recurrence intervals
- Advances in science have provided long warning times
- Any ash or lava event to affect Utah would be localized, a safe distance from population centers, and would likely have an advanced warning.

The active volcanic centers in Utah include the Escalante Deserts in the Basin and Range Province; the High Plateaus and adjacent areas in the Colorado Plateau Province; and the Pine Valley Mountains-St. George Basin and surrounding areas.

<u>Vulnerability Analysis Methodology</u>

Loss estimated provided herein used available data and the methodologies applied resulted in an approximation of risk. These estimates should be used to understand relative risk from hazards and potential losses. Uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Numerous uncertainties also result from approximation and simplifications that are necessary for a comprehensive analysis these may include incomplete inventories, demographic, economic parameters, or lack of data.

A basic synopsis of the methodology utilized to meet the requirements in DMA 2000 is discussed here with a more detailed discussion in each hazard section.

Geographic Information System (GIS) software was used as the basic analysis tool to complete the hazard analysis in all seven multi-jurisdictional plans and the state plan. For most hazards a comparison was made between available digital hazard data and census 2000 demographic information. Statewide digital data was obtained from Utah's Automated Geographic Reference Center (AGRC) for the following hazards; landslides, problem soils, quaternary faults, wildfire, dam locations, and epicenter locations. Vulnerability assessment for each county estimate the number of homes, business, infrastructure and population vulnerable to each hazard and assigns a replacement dollar value to residential structures and infrastructure in the hazard area. The value of residential housing was calculated using estimated average residential housing values for each county if parcel data was unavailable. All the analysis takes place within the spatial context of a GIS. With the information available in spatial form, it is a simple task to overlay the natural hazards with census data to extract the desired information.

Earthquake

Earthquake loss and vulnerability was profiled using HAZUS MH, which is shorthand for Hazards United States. The HAZUS MH Earthquake Model is designed to produce loss estimates for use by federal, state, regional and local governments in planning for earthquake risk mitigation, emergency preparedness, response and recovery. The methodology deals with nearly all aspects of the built environment, and a wide range of different types of losses.

Extensive national databases are embedded within HAZUS MH, containing information such as demographic aspects of the population in a study region, square footage for different occupancies of buildings, and numbers and locations of bridges. Embedded parameters have been included as needed. Using this information, users can carry out general loss estimates for a region. The HAZUS MH methodology and software are flexible enough so that locally developed inventories and other data that more accurately reflect the local environment can be substituted, resulting in increased accuracy.

Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. These factors can result in a range of uncertainty in loss estimates produced by the HAZUS MH Earthquake Model, possibly at best a factor of two or more.

The methodology has been tested against the judgment of experts and, to the extent possible, against records from several past earthquakes. However, limited and incomplete data about actual earthquake damage precludes complete calibration of the methodology.

Nevertheless, when used with embedded inventories and parameters, the HAZUS MH Earthquake Model has provided a credible estimate of such aggregated losses as the total cost of damage and numbers of casualties. The Earthquake Model has done less well in estimating more detailed results - such as the number of buildings or bridges experiencing different degrees of damage.

Such results depend heavily upon accurate inventories. The Earthquake Model assumes the same soil condition for all locations, and this has proved satisfactory for estimating regional losses. Of course, the geographic distribution of damage may be influenced markedly by local soil conditions. In the few instances where the Earthquake Model has been partially tested using actual inventories of structures plus correct soils maps, it has performed reasonably well.

The HAZUS Model estimates building losses, numbers of shelters required for displaced households, amounts of debris generated, and numbers of causalities. A HAZUS report was completed for each of the counties covered in this plan.

Dam Failure

Unfortunately, digitizing of dam failure inundation maps was not completed in time for use in the seven regional plans. I anticipate future mitigation plans will include this information. This plan utilized the dam failure inundation maps in determining if state owned facilities are in the inundation area.

Drought

Drought vulnerability in this plan is defined by rankings, which are based solely on agricultural losses. Agriculture is typically the economic sector impacted most by a drought. Economic indicators including cash receipts per county from 1990 to 2002, personal income from farming 1970-2001, number of farms per county, and number of acres of farmland per county were both used to determine a counties vulnerability to drought. These scores were all normalized and added together to create a vulnerability rating with higher numbers having higher vulnerability.

Flood

Assessing the state's vulnerability to flooding in a quantitative matter proved quite problematic. Utah has limited mapped flood plains and with the exception of Salt Lake and Utah Counties floodplain maps have not yet been digitized. Using NFIP statistics provided limited utility in determining flood vulnerability. Much of Utah's flood risk is either not mapped, mapped as Zone D (indicating the flood risk is undetermined), the city or county does not participate in the NFIP, or because people in the state perceive there is limited flood risk and/or do not believe there is a need to purchase flood insurance. Therefore, much of Utah's flood loss goes unreported. Evidence of this can be seen in the NFIP statistics; in almost 25 years, the National Flood Insurance Program paid out only $4.7 million dollars on 714 claims.

To determined flood vulnerability for each jurisdiction, state floodplain experts were assembled to provide a qualitative vulnerability assessment, classifying each county into a high, medium, or low flood vulnerability rating. Experts included the State Flood Plain

Manager, State Hazard Mitigation Officer, the U.S. Army Corps of Engineers, and members of the State Hazard Mitigation Team. Classifications were based on population, in-place flood mitigation, age and accuracy of NFIP maps, dollar amounts of infrastructure values from HAZUS MH, past flood loss, and the potential for future flooding as a result of development pressure.

Wildfire

Wildfire risk by county was determined using the Geo-processing extension in Arc View 3.2. This utility allows the GIS user to process two data sets into one new data set. In the case of wildfire the census 2000 data for municipalities was combined with the state wildfire risk data set. The ranking of counties utilizes a total of all high and extreme wildfire risk acreage for all of the cities and town in each county. Because incorporated areas typically house the majority of the human build infrastructure only those areas were summed. This method eliminates the large amount of wildfire acreage classified as extreme or high in the county from the ranking method.

Landslide

Similar to wildfire the total acreage of city land in each county with a mapped landslide was combined eliminating the large amount of landslides on county land typically owned by the federal government. So although this is a good indictor of potential landslide vulnerability total vulnerability depends on how this land is regulated. Large portions of the mapped landslides, utilized in this analysis, were on lands often valued for development. As development pressure mounts total vulnerability will be a function of how cities and counties manage the development on sensitive lands such as those with a known landslide risk.

State Owned Faculties

One of the requirements in DMA 2000 is to assess the state owned facilities and there potential vulnerability to particular hazards. At this time the state of Utah does not have a geo-coded state owned facilities list. The current table is being geocoded but this time consuming tasked did not yield a data set usable for analysis, in this iteration of the plan.

However, Utah does have a detailed Excel database with over 5,000 state owned facilities and their insured values. This database was employed were applicable to provide best estimates of damage to state owned facilities. For example this database was used to determine the number and insured value of state owned facilities in each county.

Table I-5 State Owned Facilities and There Total Insured Value

County Name	Total # of State Owned Buildings	Total Insured Value
Beaver	45	$39,699,450
Box Elder	122	$211,708,229
Cache	516	$1,002,633,308
Carbon	136	$145,275,708
Daggett	29	$9,102,956

Davis	210	$840,516,668
Duchesne	93	$102,289,698
Emery	85	$73,636,967
Garfield	60	$36,643,566
Grand	66	$38,187,807
Iron	184	$310,039,266
Juab	62	$47,790,128
Kane	54	$36,057,015
Millard	79	$87,441,289
Morgan	58	$30,834,955
Piute	25	$11,895,352
Rich	40	$12,953,729
Salt Lake	1,495	$5,045,028,405
San Juan	106	$91,054,292
Sanpete	162	$217,449,191
Sevier	110	$111,450,042
Summit	112	$165,369,028
Tooele	87	$160,620,627
Uintah	113	$118,046,950
Utah	444	$1,435,302,412
Wasatch	140	$78,873,511
Washington	151	$380,991,528
Wayne	35	$10,205,255
Weber	298	$982,416,195

Provided in Table I-6 is a breakdown, by county, of the total estimated dollar value exposed natural hazards. This information was derived using HAZUS-MH. Estimated dollar values are provided in millions for the key occupancies classes in Utah along with the number of response facilities, schools, and hospitals.

Table I-6 Total Estimated Exposed Value Per County

County Name	Residential in Millions	Non-Residential in Millions	Schools & Hospitals	Emergency Response Facilities	Total Building Value in Millions
Beaver	$297	$35	7	3	$333
Box Elder	$1,730	$255	29	12	$1,985
Cache	$3,411	$801	33	11	$4,212
Carbon	$983	$149	15	9	$1,132
Daggett	$83	$4	3	3	$88
Davis	$10,276	$1,628	94	36	$11,905
Duchesne	$628	$152	17	3	$780
Emery	$441	$84	10	11	$526
Garfield	$311	$76	11	3	$387
Grand	$386	$89	7	5	$476
Iron	$1,469	$317	15	7	$1,786
Juab	$320	$65	7	4	$386
Kane	$388	$62	8	5	$451
Millard	$504	$95	14	7	$599
Morgan	$302	$67	3	3	$369
Piute	$83	$12	3	1	$96

Rich	$246	$10	4	5	$257
Salt Lake	$40,368	$10,496	306	48	$50,865
San Juan	$527	$82	15	8	$609
Sanpete	$893	$162	15	6	$1,055
Sevier	$821	$154	18	5	$976
Summit	$2,601	$378	16	4	$2,980
Tooele	$1,802	$231	23	11	$2,034
Uintah	$955	$544	11	6	$1,199
Utah	$13,600	$2,712	130	28	$16,313
Wasatch	$860	$111	7	3	$972
Washington	$4,144	$853	34	10	$4,997
Wayne	$148	$19	1	1	$168
Weber	$8,798	$1,566	80	16	$10,365

This ranked list of counties is based on the total building values in Table I-6:

1. Salt Lake
2. Utah
3. Davis
4. Weber
5. Washington
6. Cache
7. Summit
8. Tooele
9. Box Elder
10. Iron
11. Uintah
12. Carbon
13. Sanpete
14. Sevier
15. Wasatch
16. Duchesne
17. San Juan
18. Millard
19. Emery
20. Grand
21. Kane
22. Garfield
23. Juab
24. Morgan
25. Beaver
26. Rich
27. Wayne
28. Piute
29. Daggett

<u>Estimated Insured Value of State Owned Facilities</u>

For the purpose of estimating potential loss to state owned facilities due to wildfire, landslides, and dam failure the U.S. Department of Labor Occupational Safety & Health Administration's Standard Industrial Classification (SIC) number was used. SIC codes 911102, 921102, and 919900 were separated from the June 2002 Equifax Business data set purchased by FEMA Headquarters. SIC codes were used to represent the state owned facilities. This new data set contained approximately 1,600 structures, much less actual. Although, the new dataset is not complete it does contains spatial information on most critical structures.

<u>Limitations</u>

As with any analysis the basic limitation exist those being restricted time and funding. These prevent the development of "perfect world" data for use in the analysis utilizing Geographic Information Systems. In addition to the limits in funding and time the following items limited the accuracy in the data analysis:

- Lack of digital flood plain maps
- Utah currently does not have a geo-coded list of state owned faculties.
- County Assessor data was not made available from all 29 counties.
- Predicting future losses was not attempted because of the imperfect results achieved utilizing current methods.

- Statewide hazard data was used to complete the vulnerability analysis. Much inaccuracy exists when requesting GIS systems to perform site-specific vulnerability utilizing a statewide data set.

Future analysis

Advances in GIS data and analysis methods are starting to be use by state agencies. For example the Utah Dam Safety Section is being to digitize their dam failure inundation maps and perform analysis using county assessors information. In the future mitigation plans and revisions will include:

- Dam failure loss numbers
- Detailed state owned facilities loss information
- Potential avalanche slopes
- More detailed local specific wildfire loss information

Dam Failure

Profiling Hazard Event

> ***The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.***

Dam failures result from the failure of a man made water impoundment structure, which often results in catastrophic down grade flooding. Dam failures are caused by one or a combination of the following: "breach from flooding or overtopping, ground shaking from earthquakes, settlement from liquefaction, slope failure, internal erosion from piping, failure of foundations and abutments, outlet leaks or failures, vegetation and rodents, poor construction, lack of maintenance and repair, misuse, improper operation, terrorism, or a combination of any of these" (Eldredge 46). The Utah State Engineer has been charged with regulating non-federal dams in the State, since 1919. "In the late 1970's Utah started its own Dam Safety Section within the State of Utah Engineers Office to administer all non-federal dams in response to the Federal Dam Safety Act (PL-92-367)" (Eldredge 46).

The State Dam Safety Section has developed a hazard rating system for all non-federal dams in Utah. Downstream uses, the size, height, volume, and incremental risk/damage assessments or dams are all variables used to assign dam hazard ratings in Dam Safety's classification system. Using the hazard ratings systems developed by the Dam Safety Section, dams are placed into one of three classifications high, moderate, and low. Dams receiving a low rating would have insignificant property loss do to dam failure. Moderate hazard dams would cause significant property loss in the event of a breach. High hazard dams would cause a possible loss of life in the event of a rupture. The frequency of dam inspection is designated based on hazard rating with the Division of Water Rights inspecting high-hazard dams annually, moderate hazard dams biannually, and low-hazard dams every five years. There are 906 dams in Utah of those 197 have received a high hazard rating by Dam Safety.

The rankings below were compiled as part of a hazard evaluation designed by the Federal Energy Regulatory Commission FERC. The dam rankings are assigned by a priority score with takes into account numerous variables some of, which include: public access, population at risk, breach flow, inundation depth, and dam type. The listed ranking only includes those 50 dams with the highest priority score. Figure I-3, justifies only listing the top 50 as priority scores drop dramatically there after.

1. Mountain Dell
2. Little Dell
3. Utah Power & Light Cutler
4. Quail Creek
5. Salt Lake County Sugarhouse
6. Logan First Dam
7. Quail Creek South Dam
8. Utah Power & Light Electric Lake
9. Porcupine
10. Red Butte Dam
11. Sevier Bridge
12. Panquitch Lake
13. Sand Hollow North Dam

14. Sand Hollow West Dam
15. North Utah County Tibble Fork
16. Adams
17. Twin Lakes Salt Lake County
18. Settlement Canyon
19. Utah County Thistle Creek Debris
20. DMAD
21. Gunnison Bend
22. Big Sand Wash
23. Kens Lake
24. Piute
25. Smith and Morehouse
26. Millsite
27. Sand H Debris
28. Hobbs
29. Lake Mary-Phoebe
30. Salt Lake County Big Cottonwood Spencer’s
31. Haight Creek Lower
32. Provo City-Rock Canyon DB
33. Provo City- Slate Canyon BD No. 3
34. Holmes
35. Huntington
36. Kennecott Mine Bingham Creek
37. Three Creeks- Beaver
38. Davis County-Barton Creek DB
39. Gunlock
40. Lloyds Lake-Monticello
41. Forsyth
42. Blanding City No. 4
43. Utah County-American Fork Debris
44. Kaysville
45. Mill Meadow
46. Grantsville
47. Ash Creek
48. Gunnison
49. Davis County-Stone Creek DB
50. Tony Grove Lake Dam

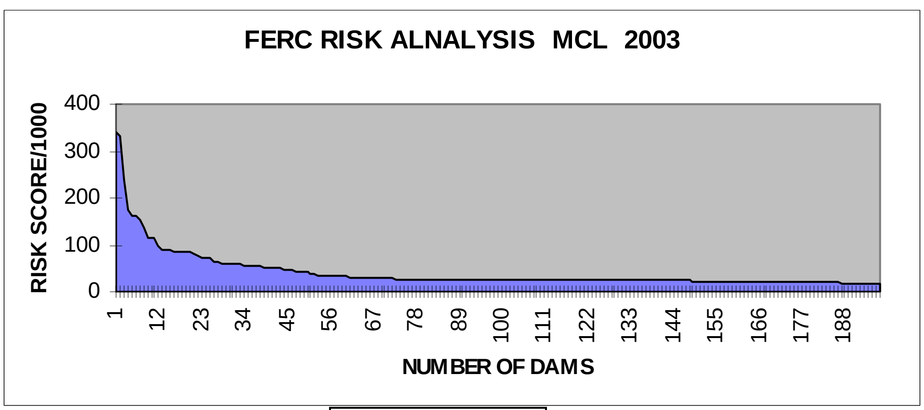


Figure I-3

Significant Dam Failure Events:

Quail Creek

Quail Creek dam failed on New Years Eve 1988 due to extensive foundation seepage. Failure caused approximately $12 million dollars in damage and cost approximately $8 million to rebuild. No lives were lost.

Trial Lake Dam Failure

Trial Lake Dam Failed in 1986 from piping of organics in the foundation contact. The BoR rebuilt the dam and the Corp fixed the damaged river channel

DMAD Dam Failure

DMAD Dam Failed in 1983 and a transient was killed trying to cross the flooding river on a suspended wire. The Gunnison Bend Dam was consequently breached proactively to keep it from overtopping.

Little Deer Creek

Little Deer Creek dam failed on its first filling on June 16, 1963, due to extensive foundation seepage. The catastrophic failure resulted in Utah's first dam failure fatality killing young Bradley Galen Brown a four-year-old boy.

Assessing Vulnerability by Jurisdiction

[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Dam-safety and dam construction, although improving, is still and imperfect subjective discipline. Many dams still fail each year in the United States. Society decided long ago the need to store water justified the risk association with storing the water. To assess vulnerability by jurisdiction the total number of dams, classified as having a high hazard rating, in each county were used to rank the jurisdictions vulnerability. Thus, a counties risk is purely a function of the number of high hazard dams in the county. Yet, one should keep in mind many factors, which can cause a dam to fail, and all dams can fail.

Salt Lake	28	Piute	6	Juab	2
Davis	27	Summit	5	Tooele	2
Utah	21	San Juan	5	Grand	2
Washington	16	Weber	4	Rich	2
Iron	11	Garfield	4	Morgan	2
Wasatch	9	Box Elder	4	Daggett	1
Sevier	9	Emery	4	Wayne	1
Uintah	8	Beaver	4	Carbon	1
Duchesne	7	Millard	3	Kane	0
Sanpete	7	Cache	3		
Total	**197**				

Estimating Potential Losses by Jurisdiction

[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…

Potential loss numbers for each jurisdiction were not completed for dam failure in the multi-jurisdictional plans. This task was not accomplished because during the planning process digitized high hazard dam inundation areas had not yet been completed.

With high hazard dam inundation areas digitized all future mitigation plans will include a section on potential losses. A mitigation strategy in this plan is to utilize the newly digitized inundation maps to better understand dam failure vulnerability.

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

A state owned facilities data set created by pulling state owned facilities out of the June 2002 Equifax Business dataset based on OSHA SIC codes was overlaid on top of dam failure inundation areas. Using the "select by theme" feature in ArcView 3.x all of the vulnerable structures intersecting the dam failures inundation areas were selected. The selected items were then saved as a theme, whose table was joined with the county FIPS codes to determine which structures are in each county.

Table I-7 Total Number of State Owned Facilities in Dam Failure Inundation Areas

County	Total Vulnerable Structures
Beaver	4
Box Elder	0
Cache	1
Carbon	0
Daggett	0
Davis	11
Duchesne	0
Emery	0
Garfield	0
Grand	19
Iron	15
Juab	0
Kane	0
Millard	6
Morgan	0
Piute	0
Rich	0

Salt Lake	111
San Juan	0
Sanpete	1
Sevier	18
Summit	1
Tooele	26
Uintah	2
Utah	57
Wasatch	6
Washington	8
Wayne	0
Weber	14
Total	**300**

Estimating Potential Losses by State Facilities

[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

Estimating values for state owned facilities in dam failure inundation areas was determined by multiplying the average insured value of state owned facilities in each county by the total number of vulnerable building in each county. Average insured value of state facilities per county was provided by State Risk Management a section of the State Department of Administrative Services.

Table I-8 Total Value of State Owned Facilities in Dam Failure Inundation Area

County	Total Vulnerable Structures	Estimated Insured Value
Beaver	4	$3,528,840.00
Box Elder	0	0
Cache	1	$1,943,087.81
Carbon	0	0
Daggett	0	0
Davis	11	$44,027,063.52
Duchesne	0	0
Emery	0	0
Garfield	0	0
Grand	19	$10,993,459.66
Iron	15	$25,274,940.15
Juab	0	0
Kane	0	0
Millard	6	$6,641,110.56
Morgan	0	0
Piute	0	0
Rich	0	0
Salt Lake	111	$374,580,704.34
San Juan	0	0

Sanpete	1	$1,342,278.96
Sevier	18	$18,237,279.60
Summit	1	$1,476,509.18
Tooele	26	$48,001,566.60
Uintah	2	$2,089,326.54
Utah	57	$184,261,796.13
Wasatch	6	$3,380,293.32
Washington	8	$20,184,981.60
Wayne	0	0
Weber	14	$46,153,780.96
Total	**300**	**$792,117,018.93**

Drought

Profiling Hazard Event

The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.

Drought is a normal recurrent feature of climate, although many, in Utah, erroneously consider it a rare and random event. It occurs in virtually all-climatic zones, while its characteristics vary significantly from one region to another. Droughts, simple put, are cumulative hazards, which result from long periods of below normal precipitation. Drought is a temporary aberration and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. The impacts of successive years of drought on reservoir storage are visible in Figure I-4.

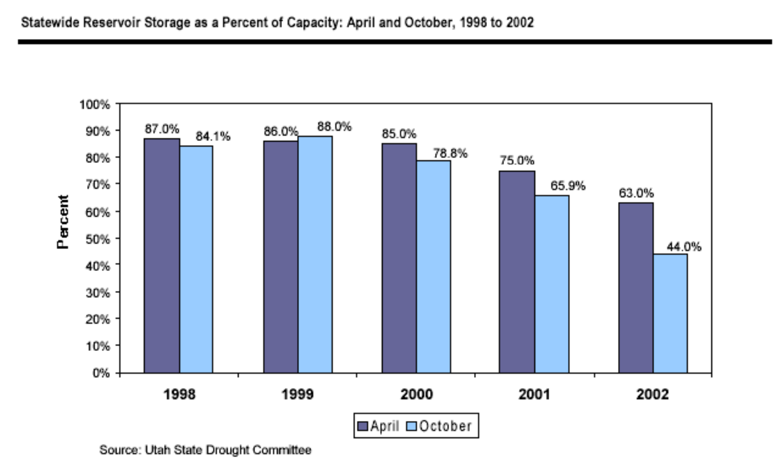
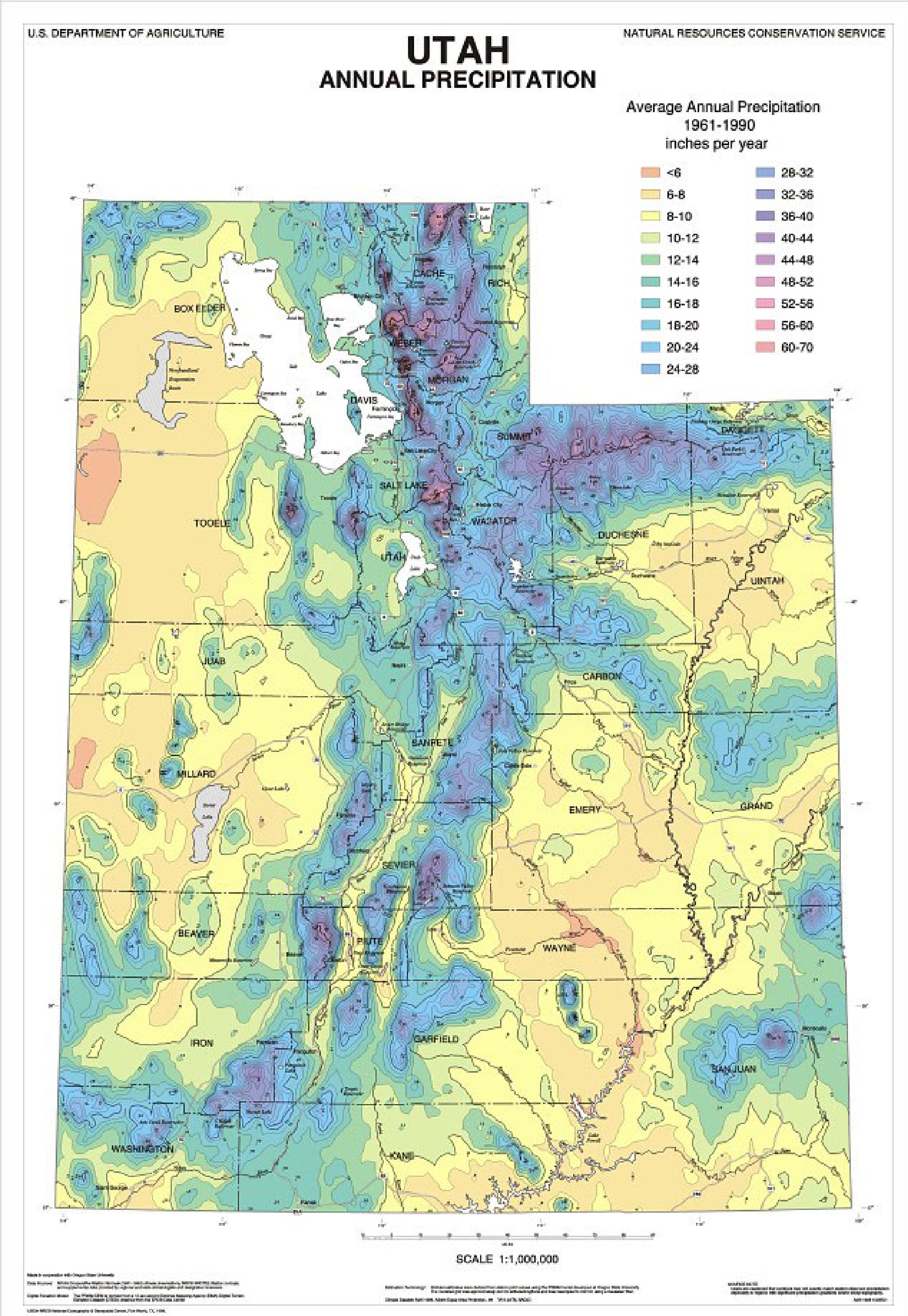


Figure I-4 Reservoir Storage

Droughts are frequently classified into one of the following four types:

1. Meteorological
2. Agricultural
3. Hydrological
4. Socio-economic

Meteorological droughts: are typically defined by the level of "dryness" when compared to an average, or normal amount of precipitation over a given period of time.
Agricultural droughts: relate common characteristics or drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors like soil water deficits; water needs based on differing stages of crop development and water reservoir levels.
Hydrological drought: is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use can alter the hydrologic characteristics of a basin.
Socioeconomic drought: is the result of water shortages that limit the ability to supply water dependent products in the marketplace.


U.S. DEPARTMENT OF AGRICULTURE
UTAH
ANNUAL PRECIPITATION
NATURAL RESOURCES CONSERVATION SERVICE
Average Annual Precipitation
1961-1990
inches per year
<6
6-8
8-10
10-12
12-14
14-16
16-18
18-20
20-24
24-28
28-32
32-36
36-40
40-44
44-48
48-52
52-56
56-60
60-70
CACHE
RICH
BOX ELDER
WEBER
MORGAN
DAVIS
SUMMIT
DAGGETT
SALT LAKE
TOOELE
WASATCH
DUCHESNE
UTAH
UINTAH
JUAB
CARBON
SANPETE
MILLARD
EMERY
GRAND
SEVIER
BEAVER
PIUTE
WAYNE
IRON
GARFIELD
SAN JUAN
WASHINGTON
KANE
SCALE 1:1,000,000

Map I-1

Impacts of Drought

Economic

- Decreased land prices
- Loss to industries directly dependent on agricultural production (machinery and fertilizer manufactures, food processors, dairies, etc)
- Unemployment from drought related declines in production
- Strain on financial institutions (foreclosures, more credit risk, capitol shortfalls)
- Revenue losses to federal, state, and local governments from reduced tax base.
- Reduction of economic development.
- Rural population loss and relocation to larger cities.
- Loss to recreation and tourism industry
- Energy related effects
- Water suppliers revenue shortfalls
- Higher cost of water transport
- Decline in food production causes increase in food prices and increase in importation of food

Social

- Mental and physical stress
- Health related low flow problems including cross-connection contamination diminished sewage flows, increased pollutant concentrations, and reduced fire-fighting capabilities.
- Loss of human life
- Public safety concerns caused by increased threat of forest and range fires
- Increases in conflicts of water users.
- Changes lifestyles of those living in rural areas.
- Reduction of modification of recreation activities.
- Public dissatisfaction with government drought response plan

Environmental

- Damage to animal species
- Reduction and degradation of fish and wildlife habitat
- Increased contact of wild animals with agricultural producers.
- Loss of biodiversity
- Lower water levels in reservoirs and lakes
- Reduced stream flow.
- Loss of wetlands
- Increased ground water depletion, land subsidence, reduced recharge.
- Increased number and severity of wild fires.
- More dust and pollutants in the air.
- Visual and landscape qualities diminished.

The State or Utah, uses the Palmer Drought Severity Index referred to as the (PDSI) to quantify the existence of a drought. Using the PDSI, drought is expressed as a negative number. Much of the basis, used by the State, to determine drought years, or drought periods, comes from the PDSI. In addition, the State Climatologist, the National Geophysical Data Center of NOAA, and the National Drought Mitigation Center use the PDSI. Further information on the Palmer Drought Severity Index can be found in Appendix F.

For the most part droughts no longer affect the availability of drinking water, thus no longer place peoples lives at risk, the same can not be said for a persons livelihood. Numerous water projects throughout the state have placed enough water in storage to insure the supply of drinking water. Yet, prolonged droughts still have a significant affect on agricultural and agribusinesses, within the state dependent on irrigation water. Droughts have significant impact on the natural world. Species over time adapt to the natural world in which they live, becoming depended on constant factors, one of those being a certain amount of water. The flora and fauna of a given area have an ability to adjust to a certain amount of environmental change but as drought conditions persist mortality rates across the ecosystem begin to rise. Prolonged droughts place a tremendous burden on wildlife habitat, causing mortality in plant species and heightening the risk of wildfire, as habitat is lost or changed, those animals depended on it, are also lost or must relocate.

According to Utah's annual PDSI averages, Utah has experienced as many as 60 years of drought out of the past 100 years, and several of these have been multi-year droughts. A more detailed look at Utah's drought is available in each of Utah's seven multi-jurisdictional Pre-Disaster Mitigation plans. These plans contain charts illustrating the Palmer Drought Severity Index for each of Utah's seven climate regions. Each chart covers the period of time from 1895 to 2003.

Table I-9 Multi-Year Droughts in Utah

1896-1905	Affected entire state
1930-1936	Dust Bowl Period; affected entire state
1939-1940	Affected entire state
1950-1951	Affected southern half of Utah
1953-1956	Affected entire state
1958-1964	Affected entire state
1970-1972	Affected southwest Utah, then entire state
1976-1979	Affected entire state
1985-1992	Affected northern Utah; then entire state
1995-1996	Affected entire state
1998-2003	Affected entire state

Droughts typically affect Utah in two ways 1) results from water shortages within reservoirs affecting irrigation and eventually culinary water supplies, if the drought lasts more than two years. 2) Soil moisture drought, where dry farmers lose their crops.

Public safety threats do no usually become visible in communities until the third year of drought, when culinary water supplies are low.

Drought Recovery

It is human nature to want to return too normal as quickly as possible. Therefore, after a prolonged drought, we look at a return to normal precipitation as the end of the drought. Indicators such as a green pasture or a full reservoir are often erroneously used to determine the end of the drought. But the effects of drought linger for several years following a return to normal precipitation. For example, we do not see, after several years of drought, that even though a plant is green it lacks vigor and that the overall biomass of the site has been reduced, therefore, land use may have to continue at a reduced level for a period following a drought. In addition soil moisture may be low inhibiting plant recovery, springs are slow to recover, and wildlife and livestock births are often reduced.

Existing Mitigation

The Department of Natural Resources Division of Water Resources plays a central role in drought mitigation and contingency planning for drought. The Division of Water Resources hosts a multi-agency governors drought advisory committee.

The Division of Water Resources also maintains the State of Utah Drought Response Plan. This plan found in Appendix G contains a comprehensive list of federal drought assistance programs and state drought-related assistance programs, as the state does not maintain a specific drought assistance program.

Assessing Vulnerability by Jurisdiction

[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Drought vulnerability rankings are based solely on agricultural, typically the economic sector hit hardest by a drought. Economic indicators including cash receipts per county from 1990 to 2002, personal income from farming 1970-2001, number of farms per county, and number of acres of farmland per county were used to determine a counties vulnerability to drought. These scores were all normalized and added together to create a vulnerability rating with higher numbers having higher vulnerability.

1. Box Elder
2. Utah
3. Cache
4. Uintah
5. Sanpete
6. Millard
7. Duchesne
8. San Juan
9. Weber
10. Beaver
11. Iron
12. Sevier
13. Summit
14. Davis
15. Salt Lake
16. Rich
17. Tooele
18. Morgan
19. Emery
20. Juab
21. Washington
22. Wayne
23. Wasatch
24. Garfield

25. Piute	27. Carbon	29. Daggett
26. Kane	28. Grand	

Estimating Potential Losses by Jurisdiction

> ***[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…***

The Governors Office of Planning and Budget compiled drought loss numbers from 2002, for the 2003 Economic Report to the Governor. The Economic Report to the Governor suggests the current drought has reduced employment change by 0.4%. During 2002, job change was –1.0%. Without the drought, job change might have been –0.6%, 0.4% higher than what actually occurred. Best estimates are that livestock sales are down $100 million due to the drought; hay sales are down $50 million; and, because of drought related fires, tourism sales are down $50 million. The combined effects of the drought in these three sectors resulted in a loss of over 6,100 jobs during 2002, and over $120 million in lost income.

The hardest hit sector was agriculture, where 2,600 jobs and almost $40 million in income were lost. The sectors serving tourists (retail trade and services) were the next hardest hit sectors. Services lost about 1,300 jobs and $25 million in income. Retail trade lost 1,000 jobs and almost $15 million in income.

It is expected droughts in the future will have similar losses. Basing future losses on past losses on the Counties of Box Elder, Utah, Cache, Uintah, Sanpete, Millard, Duchesne, San Juan, Weber, and Beaver will suffer the largest economic losses in future droughts. Drought is a compounding event, with economic losses getting larger as drought conditions persist. Utah is currently experiencing its fifth year of drought, with indicators such as snow pack, soil moisture, and weather showing no signs of relief.

Assessing Vulnerability of State Owned Facilities

> ***[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…***

Although state owned facilities are seldom threatened by drought directly, drought does increase the likelihood of wildfire. Thus, facilities at risk to wildfire are also at risk to drought as prolonged drought can heighten the wildfire risk. Drought also as an effect on the budgets of many state parks and the tourism industry relying on water based recreation such as river running and water skiing.

Earthquakes

Profiling Hazard Event

The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.

An earthquake is the abrupt shaking of the earth caused by the sudden breaking of rocks, when they can no longer withstand the stresses, built up deep beneath the earth's surface. The rocks tend to rupture along weak zones referred to as faults. When rocks break, they produce seismic waves that are transmitted through the rock outward producing ground shaking. Earthquakes are unique multi-hazard events, with the potential to cause huge amounts of damage and loss. Secondary effects of a sudden release of seismic energy (earthquake) include: ground shaking, surface fault rupture, liquefaction, tectonic subsidence, slope failure, and various types of flooding.

THE EARTHQUAKE HAZARD IN UTAH

MAGNITUDE	AVERAGE FREQUENCY IN STATE OF UTAH
3.0 or greater	6 per year
4.0 or greater	1 per year
5.0 or greater	1 every 4 years
5.5 or greater	1 every 10 years
6.0 or greater	1 every 20 years
6.5 or greater	1 every 50 years
7.0 or greater	1 every 150 years

Courtesy of University of Utah Seismograph Stations, 1996.

Figure I-5 Earthquake Frequency

<u>The Intermountain Seismic Belt</u>

The Intermountain Seismic Belt (ISB), is a zone of pronounced earthquake activity up to 120 miles wide extending in a north south direction 800 miles from Montana to northern Arizona. The Utah portion of the ISB trends from the Tremonton Cache Valley area south through the center of the state, along the Wasatch Front, and the southwest through Richfield and Cedar City concluding in St. George. "The zone generally coincides with the boundary between the Basin and Range physiographic province to the west and the Middle Rocky Mountains and Colorado Plateau physiographic provinces to the east" (Eldredge 6).

Earthquake Threats

The major secondary effects of earthquakes include: ground shaking, surface fault rupture, liquefaction, tectonic subsidence, avalanches, rock fall, slope failure, and various types of flooding. Other sections discuss landslides and flooding therefore, they will not be discussed here as an effect of earthquakes yet importance needs to be given to the fact that earthquakes can increase the likelihood of flooding and landslides.

<u>Ground Shaking</u>

Ground shaking causes the most impact during an earthquake because it affects large areas and is the origin of many secondary effects associated with earthquakes. Ground shaking, which generally lasts 10 to 30 seconds in large earthquakes, is caused by the passage of seismic waves generated by earthquakes.

Earthquakes produce both vertical and horizontal ground shaking illustrated in figure I-6. The primary or P waves are compressional; the secondary or S waves have a shear motion. These body waves radiate outwards from the fault to the ground surface where they cause ground shaking. The fast moving P waves are the first waves to cause the vibration of a building. The S waves arrive next often causing a structure to vibrate from side to side. Surface waves, characterized as Rayleigh (R) and Love (L) waves, arrive last, mainly causing low-frequency vibrations. Surface waves are more likely than P and S waves to cause tall buildings to vibrate.

Earthquake waves vary in both frequency and amplitude. High frequency low amplitude waves cause more damage to short stiff structures, were as low frequency high amplitude waves have a greater effect on tall (high-rise) structures. Ground shaking is measured using Peak Ground Acceleration (PGA). The PGA measures the rate in change of motion relative to the established acceleration due to gravity.

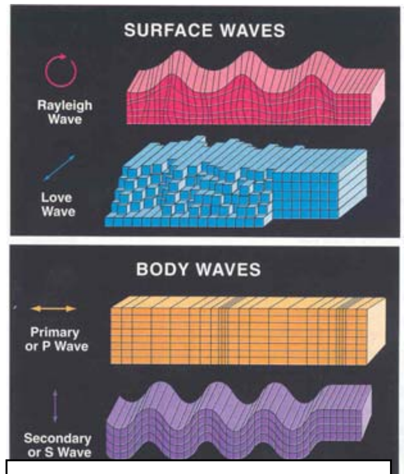


Figure I-6 Seismic waves

Local geologic conditions such as depth of sediment and sediment type, affect earthquake waves. Deep valley sediments, like those found in the Salt Lake Basin, increase the amplitude of seismic of certain frequencies relative to bedrock. In general, ground shaking increases with increased thickness of sediments" (Eldredge 8). Findings in recent geologic research done by Ivan Wong et al indicate an earthquake in Salt Lake County would produce higher PGA values than previously expected near faults and areas of near surface bedrock.

Surface Fault Rupture

During a large earthquake, fault movement may propagate along a fault plane to the surface, resulting in surface rupture along the fault. The Wasatch fault is a normal (mountain building) fault with regards to movement, meaning the footwall of the fault moves upward and the hanging wall moves in a down direction. Thus, faulting at the surface is on a steeply dipping plane, which results in the formation of large fault scarps. Surface fault rupture along the Wasatch fault is expected for earthquakes with magnitudes of 6.5 or larger. The largest probable earthquake that could strike Utah is anticipated to be an earthquake with an estimated magnitude between 7.0 and 7.5, and would most likely occur on the Wasatch Fault. An earthquake of this magnitude, based on current research, would create surface fault rupture with a displacement of around 6 to 10 feet in height and 20-40 miles long. In historic time surface fault rupture has only occurred once in Utah; the 1934 Hansel Valley earthquake with a magnitude 6.6 produced 1.6 feet of vertical offset.

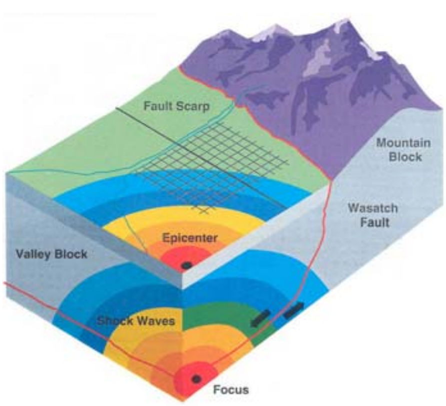


Figure I-7 Wasatch Fault block model

Surface fault rupture presents several hazards. Anything built on top of the fault or crossing the fault has a high potential of being destroyed by the event of displacement. Foundations will be cracked, building torn apart, and roads, utility lines, pipelines, or any other lifelines crossing the fault. It is almost impossible to design anything within reasonable cost parameters to withstand an estimated displacement of 6 to10 feet.

Figure I-8 Displacement in excavation

Surface fault rupture does not occur on a single distinct plane; instead, it occurs over a zone often several hundred feet wide known as the zone of deformation. The zone of deformation occurs mainly on the downthrown side of the main fault trace. Antithetic faults moving in the opposite direction of the main fault, create grabens (down dropped blocks) within the zone of deformation.

Liquefaction

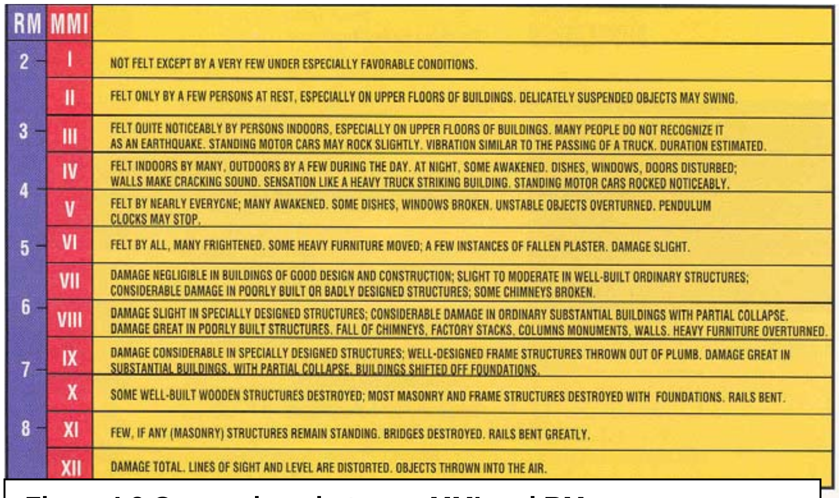
Soil liquefaction occurs when water-saturated cohesionless sandy soils are subject to ground shaking. When liquefaction occurs soils behave more like a viscous liquid (quicksand) and lose their bearing capacity and shear strength. Two conditions must be met in order for soils to liquefy: (1) the soils must be susceptible to liquefaction (sandy, loose, water-saturated, soils typically between 0 and 30 feet below the ground surface) (2) ground shaking must be strong enough to cause susceptible soils to liquefy. The loss of shear strength and bearing capacity due to liquefaction causes buildings to settle or tip and light buoyant structures such as buried storage tanks and empty swimming pools to float upward. Liquefaction can occur during earthquakes of magnitude 5.0 or greater.

Lateral Spread

Soils, once liquefied, can flow on slopes with angles of .5 to 5 percent. This movement of liquefied soils is known as lateral spread. "The surficial soil layers break up and sections move independently, and are displaced laterally over a liquefied layer" (Eldredge 10). Liquefaction can cause damage in several way, with lateral spreading being one of the most common. Displacement of three (3) or more feet may occur and be accompanied by ground cracking and vertical displacement. Lateral spreading causes roads, buildings, buried utilities, and any other buried or surface structure to be pulled apart.

Various Flooding Issues Related to Earthquakes

Earthquakes could cause flooding due to regional lowering and tilting of the valley floor (tectonic subsidence), dam failure and seiches in lakes and reservoirs. Flooding can also result from the disruption of rivers and streams. Water tanks, pipelines, and aqueducts may be ruptured, or canals and streams altered by ground shaking, surface faulting, ground tilting, and landsliding.



RM	MMI	
2	I	NOT FELT EXCEPT BY A VERY FEW UNDER ESPECIALLY FAVORABLE CONDITIONS.
	II	FELT ONLY BY A FEW PERSONS AT REST, ESPECIALLY ON UPPER FLOORS OF BUILDINGS. DELICATELY SUSPENDED OBJECTS MAY SWING.
3	III	FELT QUITE NOTICEABLY BY PERSONS INDOORS, ESPECIALLY ON UPPER FLOORS OF BUILDINGS. MANY PEOPLE DO NOT RECOGNIZE IT AS AN EARTHQUAKE. STANDING MOTOR CARS MAY ROCK SLIGHTLY. VIBRATION SIMILAR TO THE PASSING OF A TRUCK. DURATION ESTIMATED.
	IV	FELT INDOORS BY MANY, OUTDOORS BY A FEW DURING THE DAY. AT NIGHT, SOME AWAKENED. DISHES, WINDOWS, DOORS DISTURBED; WALLS MAKE CRACKING SOUND. SENSATION LIKE A HEAVY TRUCK STRIKING BUILDING. STANDING MOTOR CARS ROCKED NOTICEABLY.
4	V	FELT BY NEARLY EVERYONE; MANY AWAKENED. SOME DISHES, WINDOWS BROKEN. UNSTABLE OBJECTS OVERTURNED. PENDULUM CLOCKS MAY STOP.
5	VI	FELT BY ALL, MANY FRIGHTENED. SOME HEAVY FURNITURE MOVED; A FEW INSTANCES OF FALLEN PLASTER. DAMAGE SLIGHT.
	VII	DAMAGE NEGLIGIBLE IN BUILDINGS OF GOOD DESIGN AND CONSTRUCTION; SLIGHT TO MODERATE IN WELL-BUILT ORDINARY STRUCTURES; CONSIDERABLE DAMAGE IN POORLY BUILT OR BADLY DESIGNED STRUCTURES; SOME CHIMNEYS BROKEN.
6	VIII	DAMAGE SLIGHT IN SPECIALLY DESIGNED STRUCTURES; CONSIDERABLE DAMAGE IN ORDINARY SUBSTANTIAL BUILDINGS WITH PARTIAL COLLAPSE. DAMAGE GREAT IN POORLY BUILT STRUCTURES. FALL OF CHIMNEYS, FACTORY STACKS, COLUMNS MONUMENTS, WALLS. HEAVY FURNITURE OVERTURNED.
7	IX	DAMAGE CONSIDERABLE IN SPECIALLY DESIGNED STRUCTURES; WELL-DESIGNED FRAME STRUCTURES THROWN OUT OF PLUMB. DAMAGE GREAT IN SUBSTANTIAL BUILDINGS, WITH PARTIAL COLLAPSE. BUILDINGS SHIFTED OFF FOUNDATIONS.
	X	SOME WELL-BUILT WOODEN STRUCTURES DESTROYED; MOST MASONRY AND FRAME STRUCTURES DESTROYED WITH FOUNDATIONS. RAILS BENT.
8	XI	FEW, IF ANY (MASONRY) STRUCTURES REMAIN STANDING. BRIDGES DESTROYED. RAILS BENT GREATLY.
	XII	DAMAGE TOTAL. LINES OF SIGHT AND LEVEL ARE DISTORTED. OBJECTS THROWN INTO THE AIR.

Figure I-9 Comparison between MMI and RM

Seiches

Standing bodies of water are susceptible to earthquake ground motion. Water in lakes and reservoirs may be set in motion and slosh from one end to the other, much like in a bathtub. This motion is called a seiche (pronounced "saysh"). A seiche may lead to dam failure or damage along shorelines.

Earthquake Measurement

An earthquake's size is measured in two ways. One is by their magnitude, which is a measure of the amplitude of the seismic waves, the second is by their intensity, a measure of the damaged caused by the quake. The Richter Magnitude scale, a logarithmic scale where every whole number increase represents a ten-fold increase in recorded ground motion, is used to measure magnitude. The Modified Mercalli Intensity Scale (MMI) is used to measure intensity. Developed in 1902 by an Italian scientist named G. Mercalli this scale is based on observations of damage. Figure I-9 illustrates the relationship between the Richter Magnitude and the Modified Mercalli Intensity.

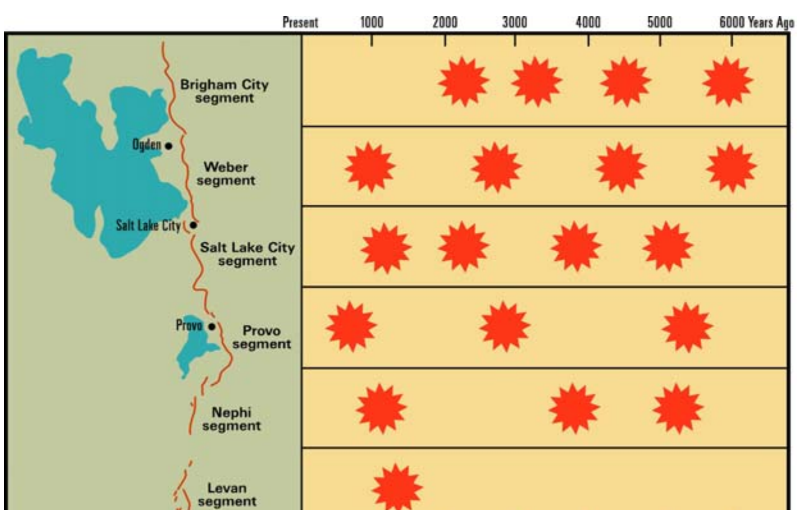


Figure I-10 Movement along each segment of the Wasatch Fault

Significant Earthquakes:

Every year, seismograph stations record about 700 earthquakes occurring in Utah. Most of these are too small to even be felt. Figure I-5 demonstrates the average frequency of earthquakes in Utah. Utah has numerous active faults throughout the state, capable of causing damage, but due to the number of people residing along the Wasatch Front and the amount of infrastructure, an event on the Wasatch Fault would cause the most damage. The last known movement of each segment of the Wasatch Fault is shown in figure I-10. Table I-10 provides a timeline of all earthquakes larger then 5.0 magnitude, occurring in Utah from 1876 to present.

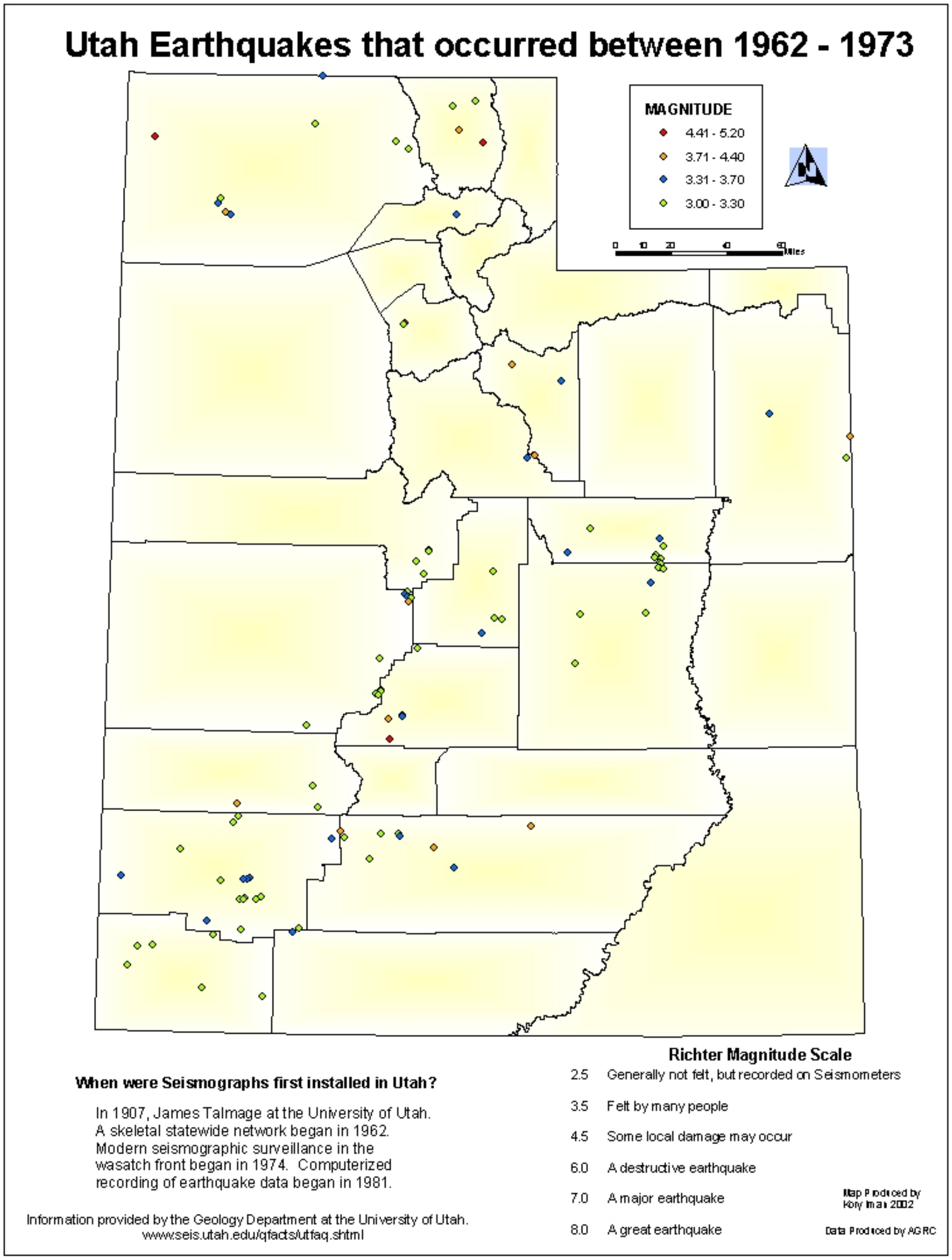
Illustrated in maps I-2, 3, and 4 are the location of earthquakes from 1962 through 1992 larger than 3.0, while slightly dated these maps provide spatial reference to seismically active areas.

Table I-10 Significant Utah Earthquakes

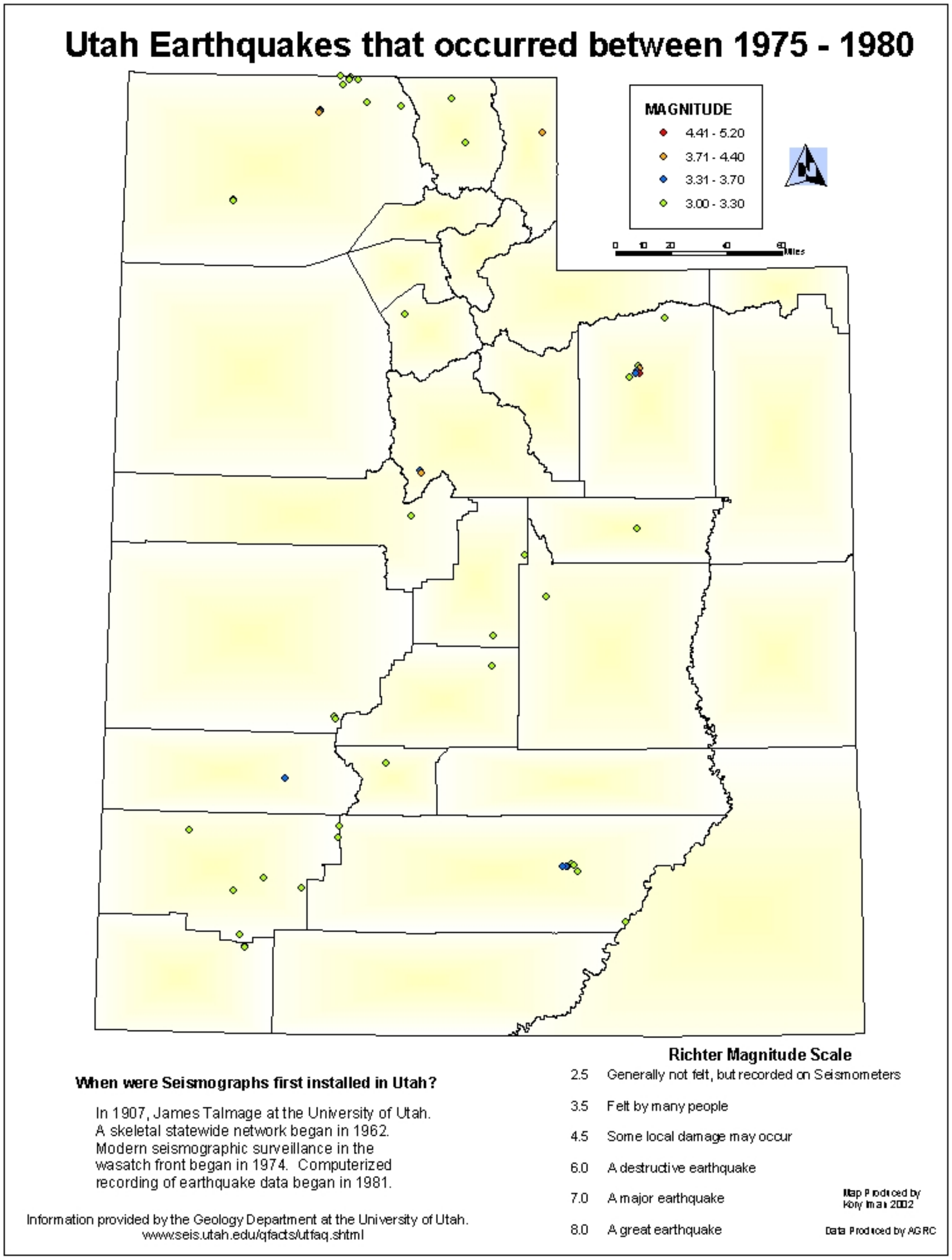
Date	Name	Magnitude
March 22, 1876	Moroni	5.0
December 5, 1887	Kanab	5.7
April 20, 1891	St. George	5.0
July 18, 1894	Ogden	5.0
August 1, 1900	Eureka	5.0 +/- .5
November 13, 1901	Southern Utah	6.0 +/- .5
November 17, 1902	Pine Valley	6.0
April 15, 1908	Milford	5.0
October 5, 1909	Hansel Valley	6.0
January 10, 1910	Elsinore	5.0
May 22, 1910	Salt Lake City	5.5
May 13, 1914	Ogden	5.0 +/- .5
July 15, 1915	Provo	5.0
September 29, 1921	Elsinore	6.0
January 20, 1933	Parowan	5.0
March 12, 1934	Hansel Valley	6.6
August 30, 1942	Cedar City	5.0
September 26, 1942	Cedar City	5.0
February 22, 1943	Magna	5.0
November 17, 1945	Glenwood	5.0
March 6, 1949	Salt Lake City	5.0
February 13, 1958	Wallsburg	5.0
February 27, 1959	Panquitch	5.0
July 21, 1959	Southwest	5.7
April 15, 1961	Ephraim	5.0
August 30, 1962	Cache Valley	5.7
September 5, 1962	Magna	5.2
October 4, 1967	Marysvale	5.2
August 14, 1988	San Rafael Swell	5.3
January 29, 1989	Wasatch Plateau	5.4
September 2, 1992	St. George	5.8

*Occurred in Idaho felt in throughout northern Utah

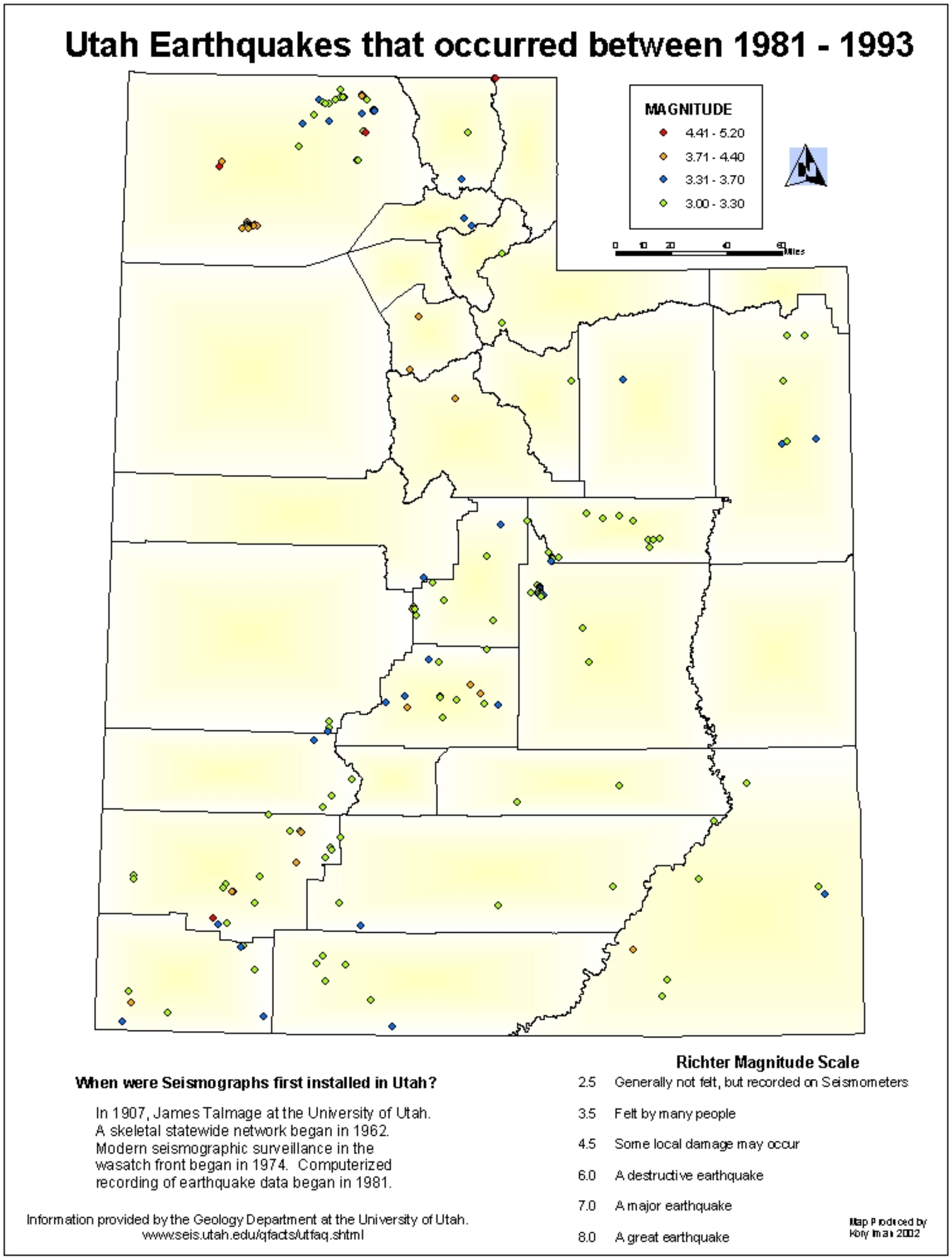
Table derived form information provided by the University of Utah Seismograph Stations.


Utah Earthquakes that occurred between 1962 - 1973
MAGNITUDE
4.41 - 5.20
3.71 - 4.40
3.31 - 3.70
3.00 - 3.30
Miles
When were Seismographs first installed in Utah?
In 1907, James Talmage at the University of Utah.
A skeletal statewide network began in 1962.
Modern seismographic surveillance in the
wasatch front began in 1974. Computerized
recording of earthquake data began in 1981.
Information provided by the Geology Department at the University of Utah.
www.seis.utah.edu/qfacts/utfaq.shtml
Richter Magnitude Scale
2.5 Generally not felt, but recorded on Seismometers
3.5 Felt by many people
4.5 Some local damage may occur
6.0 A destructive earthquake
7.0 A major earthquake
8.0 A great earthquake
Map Produced by
Data Produced by AGRC

Map I-2


Utah Earthquakes that occurred between 1975 - 1980
MAGNITUDE
4.41 - 5.20
3.71 - 4.40
3.31 - 3.70
3.00 - 3.30
Miles
Richter Magnitude Scale
2.5 Generally not felt, but recorded on Seismometers
3.5 Felt by many people
4.5 Some local damage may occur
6.0 A destructive earthquake
7.0 A major earthquake
8.0 A great earthquake
When were Seismographs first installed in Utah?
In 1907, James Talmage at the University of Utah.
A skeletal statewide network began in 1962.
Modern seismographic surveillance in the
wasatch front began in 1974. Computerized
recording of earthquake data began in 1981.
Information provided by the Geology Department at the University of Utah.
www.seis.utah.edu/qfacts/utfaq.shtml
Map Produced by
Data Produced by AGRC

Map I-3


Utah Earthquakes that occurred between 1981 - 1993
MAGNITUDE
4.41 - 5.20
3.71 - 4.40
3.31 - 3.70
3.00 - 3.30
0 10 20 40 60 Miles
When were Seismographs first installed in Utah?
In 1907, James Talmage at the University of Utah. A skeletal statewide network began in 1962. Modern seismographic surveillance in the wasatch front began in 1974. Computerized recording of earthquake data began in 1981.
Information provided by the Geology Department at the University of Utah.
www.seis.utah.edu/qfacts/utfaq.shtml
Richter Magnitude Scale
2.5 Generally not felt, but recorded on Seismometers
3.5 Felt by many people
4.5 Some local damage may occur
6.0 A destructive earthquake
7.0 A major earthquake
8.0 A great earthquake
Map Produced by

Map I-4

Assessing Vulnerability by Jurisdiction

> ***[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…***

County vulnerability ranking is solely based on the total building related economic loss that would occur from a 2500-year seismic event in each county.

1. Salt Lake
2. Utah
3. Davis
4. Weber
5. Washington
6. Cache
7. Summit
8. Tooele
9. Box Elder
10. Iron
11. Uintah
12. Carbon
13. Sanpete
14. Sevier
15. Wasatch
16. Duchesne
17. San Juan
18. Millard
19. Emery
20. Grand
21. Kane
22. Garfield
23. Juab
24. Morgan
25. Beaver
26. Rich
27. Wayne
28. Piute
29. Daggett

Estimating Potential Losses by Jurisdiction

> ***[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…***

HAZUS MH, a model developed by FEMA to replicate earthquake loss, was used to estimate vulnerability. HAZUS MH was used to model ground-shaking levels with a 2500-year return period for each county. Compiled in table I-11 are some of the more pertinent loss values, from the HAZUS MH runs.

Table I-11 County Earthquake Loss Value from HAZUS MH

County Name	Building Related Economic Losses Residential in Millions	Building Related Economic Losses Non-Residential in Millions	Total Casualties Estimates for 2AM	Fatalities 2AM	Total Building Related Economic Losses in Millions
Beaver	$56.63	$14.08	51	2	$70.71
Box Elder	$413.68	$134.7	514	25	$548.37
Cache	$641	$340.27	816	39	$981.26
Carbon	$121.15	$46.2	3	0	$167.35
Daggett	$6.38	$0.67	2	0	$7.06
Davis	$3,009.21	$1,036.15	3680	183	$4,045.36
Duchesne	$40.56	$11.52	35	1	$52.09
Emery	$78.24	$25.43	88	3	$103.67
Garfield	$65.97	$40.51	54	2	$106.48

County Name	Building Related Economic Losses Residential in Millions	Building Related Economic Losses Non-Residential in Millions	Total Casualties Estimates for 2AM	Fatalities 2AM	Total Building Related Economic Losses in Millions
Grand	$14.16	$6.84	1	0	$21
Iron	$349.54	$139.43	370	17	$488.96
Juab	$45.03	$25.96	54	3	$70.98
Kane	$41.75	$17.29	34	1	$59.04
Millard	$46.69	$21.5	48	2	$68.19
Morgan	$38.7	$20.4	41	2	$59.09
Piute	$18.31	$5.48	15	1	$23.78
Rich	$34.05	$3.36	14	1	$37.41
Salt Lake	$12,978.45	$7,252.62	15310	756	$20,231.07
San Juan	$10.18	$2.38	8	0	$12.57
Sanpete	$132.25	$87.6	153	7	$181.49
Sevier	$124.92	$50.91	127	5	$175.83
Summit	$374.94	$136.76	209	10	$511.7
Tooele	$236.74	$76.01	258	11	$312.75
Uintah	$72.38	$33.42	60	2	$105.8
Utah	$3,491.86	$1,568.72	168	11	$5,060.58
Wasatch	$96.68	$33.23	75	3	$129.91
Washington	$613.58	$279.54	621	25	$893.12
Wayne	$13.31	$3.54	8	0	$16.85
Weber	$2,451.35	$1,004.53	2957	149	$3,455.87
Total	$25,617.69	$12,419.05	25774	1261	$37,998.34

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

When assessing the vulnerability of state owned facilities, or all facilities for that matter, an understanding of the building code, to which the building was designed, is of extreme importance. Utah building codes began to address seismic design as early as 1976 although the state did not adopt building codes fully addressing seismic safety until 1989. It is a fairly safe assumption that buildings constructed prior to 1976 will not perform in an earthquake as well as those building constructed following 1976. An increased understanding of seismic events coupled with advances in building design has greatly increased our ability to design and construct buildings, which perform better in earthquakes. Safer buildings are a result of scientific gains in the fields of geoscience and structural engineering, being accepted and put in practice through building codes. Thus, buildings constructed today will have a superior performance in an earthquake than those constructed in the past.

Earthquakes are regional hazards effecting multi-county areas, and because almost the entire state could experience a seismic event, all of the state owned buildings exhibit some degree of risk due to the event. The degree of risk is determined by several factors none more important than the likelihood and potential magnitude of the earthquake, although when discussing potential building damage regardless of location, building design is a key factor. Vulnerability of state owned facilities was determined through age of construction with those buildings built before 1976 considered having a higher risk. Shown in table E-3 is the number of state buildings in each county built prior to1976 and those built post 1976.

Table I-12 Number of State Owned Facilities per County Built pre and post 1976

County Name	Number of state owned buildings consider high risk pre 1976 construction date	Number of state owned buildings consider to have a lower risk post 1976 construction date
Beaver	17	27
Box Elder	53	71
Cache	245	270
Carbon	54	82
Daggett	10	19
Davis	74	136
Duchesne	29	64
Emery	34	51
Garfield	28	32
Grand	29	37
Iron	57	127
Juab	17	45
Kane	17	37
Millard	24	56
Morgan	22	36
Piute	9	16
Rich	14	26
Salt Lake	571	924
San Juan	29	77
Sanpete	38	125
Sevier	36	74
Summit	17	96
Tooele	23	64
Uintah	42	71
Utah	165	279
Wasatch	38	102
Washington	39	112
Wayne	20	14
Weber	151	147
Total	1,902	3217

Estimating Potential Losses by State Facilities

[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

To estimate the potential losses a seismic event would cause to state owned facilities, age of construction was again a central element. This time the construction date of a building was utilized to determine the value or expected damage as based on the building's insured value. To determine the value of vulnerable state-owned facilities, the state-owned building database was queried to identify the number of buildings, age of building construction, and insured value of those buildings for each county. The insured value was then used to determine estimated building damage that would result from an event with ground motion of 0.25 and 0.55 PGA. Loss estimation tables from FEMA publication 386-2 "Understanding Your Risk - identifying hazards and estimating losses" were utilized to obtain the percentage of damage expected at the two different PGA values. Rather than determine the building type of all 5119 state-owned facilities the values in Table E-4 are for reinforced masonry structures. We assumed moderate building code construction for those structures built after 1976 and pre-code construction for those structures build before 1976. Values in table E-4, assume damage estimates of 3.9 and 12.4 percent at 0.25 PGA and 27.7 and 53.1 at 0.55 PGA. Content values were not figured into table I-13, as they are most likely included in the insured value. This may have slightly increased the expected damage because as a rule content valued is one half of the expected building damage.

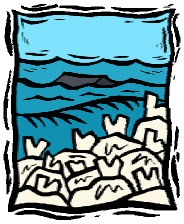
For example, building damage for pre-code construction with a ground motion event of 0.55 PGA has an estimated percent damage of 53.1. One would estimate that the contents damage would be 26.55 percent of the building's replacement value.

Table I-13 Potential Damage to State Owned Facilities

County Name	Insured value	Expected building damage at 0.25 PGA (g)	Expected building damage at 0.55 PGA (g)
Beaver	$26,371,416	$ 1,028,485.22	$ 7,304,882.23
Pre 1976	$13,328,034	$1,652,676.22	$7,077,186.05
Box Elder	$75,837,338	$2,957,656.18	$21,006,942.63
Pre 1976	$135,870,891	$16,847,990.48	$72,147,443.12
Cache	$371,855,177	$14,502,351.90	$103,003,884.03
Pre 1976	$630,778,131	$78,216,488.24	$334,943,187.56
Carbon	$4,068,120	$158,656.68	$1,126,869.24
Pre 1976	$83,112,148	$10,305,906.35	$44,132,550.59
Daggett	$5,034,836	$196,358.60	$1,394,649.57
Pre 1976	$4,068,120	$504,446.88	$2,160,171.72
Davis	$366,764,486	$14,303,814.95	$101,593,762.62
Pre 1976	$473,752,182	$58,745,270.57	$251,562,408.64
Duchesne	$34,473,051	$1,344,448.99	$9,549,035.13
Pre 1976	$67,816,647	$8,409,264.23	$36,010,639.56

County Name	Insured value	Expected building damage at 0.25 PGA (g)	Expected building damage at 0.55 PGA (g)
Emery	$33,360,826	$1,301,072.21	$9,240,948.80
Pre 1976	$35,387,341	$4,388,030.28	$18,790,678.07
Garfield	$19,465,471	$759,153.37	$5,391,935.47
Pre 1976	$17,178,095	$2,130,083.78	$9,121,568.45
Grand	$15,553,531	$606,587.71	$4,308,328.09
Pre 1976	$22,634,276	$2,806,650.22	$12,018,800.56
Iron	$199,172,583	$7,767,730.74	$55,170,805.49
Pre 1976	$110,866,683	$13,747,468.69	$58,870,208.67
Juab	$40,790,927	$1,590,846.15	$11,299,086.78
Pre 1976	$6,999,201	$867,900.92	$3,716,575.73
Kane	$20,349,221	$793,619.62	$5,636,734.22
Pre 1976	$15,707,794	$1,947,766.46	$8,340,838.61
Millard	$65,663,568	$2,560,879.15	$18,188,808.34
Pre 1976	$21,777,721	$2,700,437.40	$11,563,969.85
Morgan	$15,202,016	$592,878.62	$4,210,958.43
Pre 1976	$15,632,939	$1,938,484.44	$8,301,090.61
Piute	$3,878,328	$151,254.79	$1,074,296.86
Pre 1976	$9,939,684	$1,232,520.82	$5,277,972.20
Rich	$5,407,528	$210,893.59	$1,497,885.26
Pre 1976	$7,546,201	$935,728.92	$4,007,032.73
Salt Lake	$2,681,862,908	$104,592,653.41	$742,876,025.52
Pre 1976	$2,363,165,497	$293,032,521.63	$1,254,840,878.91
San Juan	$42,398,548	$1,653,543.37	$11,744,397.80
Pre 1976	$48,655,744	$6,033,312.26	$25,836,200.06
Sanpete	$171,819,118	$6,700,945.60	$47,593,895.69
Pre 1976	$45,630,073	$5,658,129.05	$24,229,568.76
Sevier	$71,018,002	$2,769,702.08	$19,671,986.55
Pre 1976	$40,432,040	$5,013,572.96	$21,469,413.24
Summit	$158,254,746	$6,171,935.09	$43,836,564.64
Pre 1976	$7,114,282	$882,170.97	$3,777,683.74
Tooele	$80,451,484	$3,137,607.88	$22,285,061.07
Pre 1976	$80,169,143	$9,940,973.73	$42,569,814.93
Uintah	$71,050,468	$2,770,968.25	$19,680,979.64
Pre 1976	$46,996,482	$5,827,563.77	$24,955,131.94
Utah	$869,253,106	$33,900,871.13	$240,783,110.36
Pre 1976	$566,049,306	$70,190,113.94	$300,572,181.49
Wasatch	$43,178,642	$1,683,967.04	$11,960,483.83
Pre 1976	$35,694,869	$4,426,163.76	$18,953,975.44
Washington	$291,174,090	$11,355,789.51	$80,655,222.93
Pre 1976	$89,817,438	$11,137,362.31	$47,693,059.58
Wayne	$2,105,608	$82,118.71	$583,253.42
Pre 1976	$8,099,647	$1,004,356.23	$4,300,912.56
Weber	$338,871,627	$13,215,993.45	$93,867,440.68
Pre 1976	$643,544,568	$79,799,526.43	$341,722,165.61
Total	$11,772,451,947	$939,185,665.98	$4,695,501,544.28

Damage estimates utilized tables from FEMA 386-2. Values following the county name are for buildings constructed post 1976.



Flooding

Profiling Hazard Event

The risk assessment shall include an overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.

Flooding
is a temporary overflow of water onto lands not normally inundated by water producing measurable property damage or forcing evacuation of people and vital resources. Floods frequently cause loss of life; property damage and destruction; damage and disruption of communications, transportation, electric service, and community services; crop and livestock damage and loss, and interruption of business. Floods also increase the likelihood of hazard such as transportation accidents, contamination of water supplies, and health risk increase after a flooding event.

Several factors determine the severity of floods including rainfall intensity, duration and rapid snowmelt. A large amount of rainfall over a short time span can result in flash flood conditions. Small amounts of rain can also result in flooding at locations where the soil has been previously saturated or if rain concentrates in an area having, impermeable surfaces such as large parking lots, paved roadways, or post burned areas with hydrophobic soils. Topography and ground cover are also contributing factors for floods. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover.

Frequency of inundation depends on the climate, soil, and channel slope. In regions where substantial precipitation occurs during a particular season or in regions where annual flooding is due to spring melting of winter snow pack, areas at risk may be inundated nearly every year.

Utah, in recent years has seen a new kind of flood risk emerge, that of canal failures and flooding and debris flows related to watersheds damaged by wildfire. This type of flooding is distinctly different from the floods normally dealt with. As Utah continues the move from rural predominantly farmland to urban areas large amounts of land traditionally used for framing is being converted to residential development. This development, occurring in a patchwork fashion, is leaving irrigation canals in place to transport water to undeveloped farms. This is placing residential development near and often below un-engineered irrigation canals. Irrigation canals have a history of breaching, yet development pressure has now put homes at the base of many of these canals.

Post fire related flooding results from enhanced runoff from fire damaged watershed. As fires burn they destroy vegetation and often leave soils in a hydrophobic state, this alters the hydrology of the watershed, producing greater peak flows. It takes the human built environment to turn a natural event into a natural disaster. Development on the foothill all along the Wasatch Front is occurring, at rapid rates. Foothill property is considered prime real estate and is more often than not in URWIN areas on step slopes. This serious problem of debris flows and the elevated risk of debris flow following a wildfire; is discussed further in the landslide section.

Conditions which my exacerbate floods

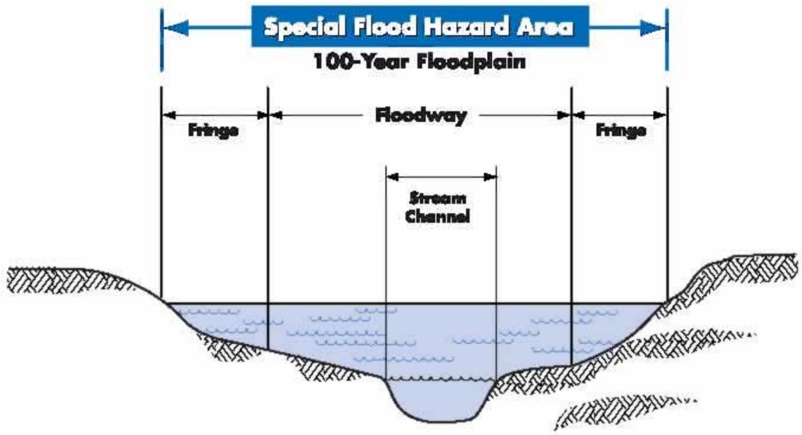
Impermeable surfaces	Debris
Steeply sloped watersheds	Contamination
Constrictions	Soil saturation
Obstructions	Velocity

Source: http://www.fema.gov/nfip

Explanation of Common Flood Terms

FIRM: Flood Insurance Rate Map

Fringe:
The portion of the 1-percent-annual-chance (100 year) floodplain that is not within the regulatory floodway and in which development and other forms of encroachment may be permitted under certain circumstances.



Stream Channel:
A naturally or artificially created open conduit that periodically or continuously contains moving water or which form a connecting link between two bodies of water

100-year flood: Applies to an area that has a 1 percent chance, on average, of flooding in any given year. However, a 100-year flood could occur two years in a row, or once every 10 years. The 100-year-flood is also referred to as the base flood.

Base Flood: Is the standard that has been adopted for the NFIP. It is a national standard that represents a compromise between minor floods and the greatest flood likely to occur in a given area and provides a useful benchmark.

Base Flood Elevation (BFE): As shown on the FIRM, is the elevation of the water surface resulting from a flood that has a 1% chance of occurring in any given year. The BFE is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum (NGVD) or 1929, the North American Vertical Datum (NAVD) of 1988, or other datum referenced in the FIS report.

Special Flood Hazard Area (SFHA): Is the shaded area on a FIRM that identifies an area that has a 1% chance of being flooded in any given year (100-year floodplain).

Flood Recurrence	Chance of occurrence in any given year
10 year	10%
50 year	2%
100 year	1%
500 year	0.20%

Floodway: Is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without raising that water surface elevation by more than one foot.

Major Floods in Utah

Major floods are those that are extensive and have large recurrence intervals (greater than 25 years). These major events and additional floods of a more local nature are listed chronologically in Table F-1. Stream flow records from six stream flow-gauging stations depict major floods in Utah. The selected gauging stations are on streams that represent natural runoff in Utah's principal river basins. Data from the gauging stations are collected, stored, and reported by water year (a water year is the 12-month period from October 1 through September 30 and is identified by the calendar year in which it ends).

Many other floods in Utah have been severe locally and have affected considerably smaller areas than the areas of those floods identified in Table I-14. Some of these local floods have caused substantial loss of life and property damage.

Table I-14 Chronology of major and other memorable floods in Utah, 1884-1988

Flood	Date	Area Affected	Recurrence Interval (in years)	Remarks
Flood	July 4, 1884	Colorado River	>100	Probably snowmelt combined with rainfall
Flood	Aug. 13, 1923	Tributaries to Great Salt Lake between Ogden and Salt Lake City.	Unknown	Locally intense thunderstorms. Deaths, 7; damage, $3,000,000
Flood	Apr. 28-June 11, 1952	Strawberry, upper Price, upper San Rafael, Ogden, Weber, Provo, and Jordan Rivers; Blacksmith Fork, and Spanish Fork; upper Muddy and Chalk Creeks.	25 to >100	Melting of snowpack having maximum-of-record water content for Apr. 1. Disaster declared. Deaths, 2; damage, $8.4 million.
Flood	June 16, 1963	Duchesne River	>100	Dam failure
Flood	June 10-11, 1965	Ashley Creek and other streams between Manila and Vernal and west of Manila.	>100	Three days of intense rainfall on thick snowpack above altitude 9,200 feet. Deaths, 7; damage, $814,000.
Flood	Dec. 6- 7, 1966	Virgin and Santa Clara Rivers.	25 to >100	Four days of light to intense rainfall of as much as 12 inches. Damage, $1.4 million.

Flood	Aug. 1- 2, 1968	Cottonwood Wash and other nearby tributaries to San Juan River.	50 to >100	Locally intense thunderstorms following 11 days of rainfall. Damage, $34,000.
Flood	Sept. 5- 7, 1970	San Juan River and tributaries from McElmo Creek to Chinle Creek.	25 to >100	Record breaking rainfall. Deaths, 2; damage, $700,000.
Flood	Aug. 27, 1972	Vernon Creek	>100	Locally intense thunderstorms.
Flood	Apr. 10- June 25, 1983	Lower Duchesne and Jordan Rivers and tributaries (including Spanish Fork); upper Price, Bear, Sevier, and San Pitch Rivers; Chalk, East Canyon, Trout, and George Creeks; Great Salt Lake and tributaries between Ogden and Salt Lake City.	25 to >100	Rapid melting of snowpack having maximum-of-record water content for June 1. Disaster declared by President. Damage, $621 million.
Flood	Apr. 17- June 20, 1984	White, upper Price, and Fremont Rivers; lower Bear and Sevier Rivers and tributaries; Beaver River; Red Butte Creek; Spanish Fork; Jordan River.	25 to >100	Runoff from greater than average snowpack for Apr. 1 and spring precipitation. Deaths, 1; damage, $41 million.
Flood	May 22, 1984	Sevier Lake	Unknown	Runoff in Sevier River from Nov. 1982 through June 1984 exceeded upstream reservoir capacity; about 1.5 million acre-feet of water conveyed to Sevier Lake. On May 22, 1984 lake reported to be as much as 35 feet deep after being nearly dry since about 1880.
Flood	June 15, 1984	Utah Lake	Unknown	Runoff from greater than normal precipitation since Sept. 1982 increased lake level to 101-year record of 5.46 feet above compromise level on June 15, 1984. Damage, $5.9 million.
Flood	June 3, 1986	Great Salt Lake	Unknown	Large runoff from greater than normal precipitation since Sept. 1982 increased lake level to 140-year record elevation of 4,211.85 feet on June 3, 1986. Damage, $268 million.

FLOODS

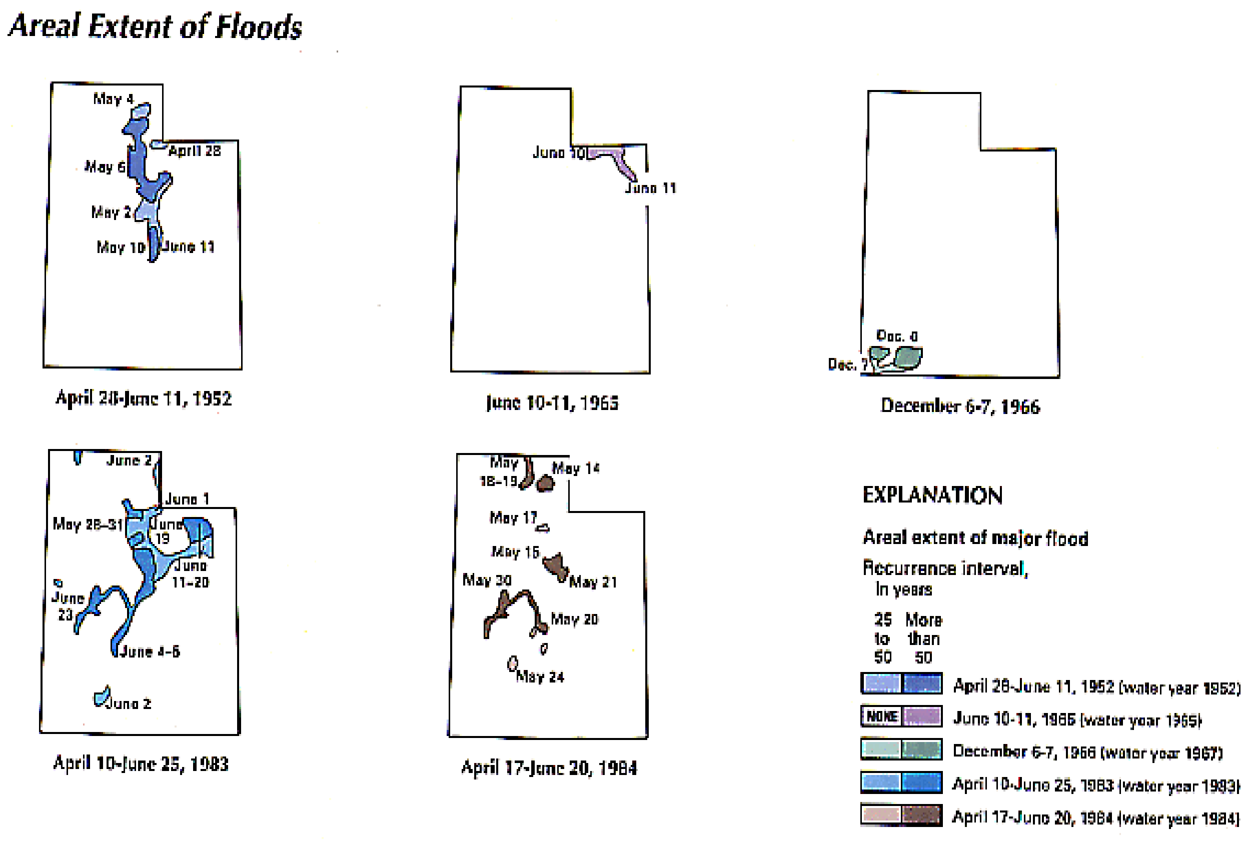


Figure I-10. Aerial Extent of Floods in Utah.

The five major floods of record occurred in 1952,1965, 1966, 1983, and 1984. The aerial extent and severity of these floods are determined from six gauging stations.

The April 28, 1952, flooding on Chalk Creek at Coalville and other flooding during the extensive April 28-June 11, 1952, floods were caused by melting, of maximum-of-record snowpack for April 1 (U.S. Soil Conservation Service, 1983). Flooding was severe in central and north-central Utah (figure I-10), and a flood disaster was declared. Two lives were lost in boating accidents on the swollen Ogden River (Wells, 1957, p. 597-613). Flood damage was $8.4 million, of which $1.9 million was in Salt Lake City.

Rainfall on melting snowpack caused the June 11,1965, flood on Ashley Creek near Vernal and the June 10-11, 1965, floods in northeastern Utah. Flooding also was severe on several other streams in the Uinta Mountains near Vernal and Manila. Areas at altitudes above 9,200 feet contributed most to the flooding. During the flood, the snowline receded from about 9,200 to 9.900 feet. Peak discharges were greater than the discharge expected to recur once in 100 years on Ashley Creek on the southern slope of the Uinta Mountains and on streams on the northern slope. On a creek southwest of

Manila, floodwaters that were the most severe in 40 years swept away and killed seven campers during the night. Within the storm area, flooding caused estimated damage of $814,000 to roads, bridges, irrigation canals, fences, and crops. (Rostvedt and others, 1970, p. E54-E57).

December 6, 1966 (water year 1967), a flood on the Santa Clara River near Pine Valley occurred. A rainstorm during December 3-6 was of unprecedented aerial coverage and intensity for extreme southwestern Utah. Rainfall in the storm area ranged from about 1 to 12 inches. Peak discharges on the Virgin and Santa Clara Rivers and other streams in the storm area had recurrence intervals that exceeded 100 years. Aerial extent of the flooding is shown in Figure F-1. Total damage to crops, fences, roads, bridges, diversion structures, cropland, forestlands, and improvements was about $ 1.4 million (Butler and Mundorff, 1970, p. A-l9).

The floods of April 10-June 25, 1983, affected 22 counties, or more than three-fourths of the State. On April 10, a landslide caused by precipitation dammed the Spanish Fork, which then inundated the community of Thistle. The landslide, which resulted in damage of about $200 million and a Presidential disaster declaration, was the most costly geologic phenomenon in Utah's history (Utah Division of Comprehensive Emergency Management, 1985, p. 40).

Rapid melting of snowpack that had maximum-of-record water content for June 1 (U.S. Soil Conservation Service. 1983) resulted in the largest and most widespread flooding in the State’s history; peak discharges had recurrence intervals that exceeded 100 years on several streams. New discharge records were set on many others, such as Chalk Creek at Coalville. On June 23, the Delta-Melville-Abraham-Deseret Dam on the Sevier River near Delta failed because of the flooding on June 23, 1983, and released 16,000 acre-feet of water down the river. Two bridges were washed away, and the town of Deseret was inundated by as much as 5 feet of water (Utah Division of Comprehensive Emergency Management, 1985, p. 41).

Overall damage from the April 10- June 25, 1983, floods totaled $621 million (Stephens, 1984, p. 20-36). No deaths were attributed to the floods.

The May 24, 1984, flood on the Beaver River near Beaver and other flooding during the April 17- June 20,1984, floods caused damage second in magnitude only to damage in 1983. The major cause of the flooding was much greater than average snowpack and greater than normal precipitation that continued throughout the spring. Peak discharges exceeded those in 1983 at some sites on the White, Bear, Jordan, and Beaver Rivers. Owing to severe flooding in 12 counties, a disaster was declared by the President. On May 14, rainfall caused a mudslide near the coal-mining town of Clearcreek that killed one person and injured another. The direct impact on people was considerably less in 1984 compared to 1983 because of mitigation measures implemented during the previous year. Total damage for floods and landslides was estimated to be $41 million (Utah Division of Comprehensive Emergency Management, 1985, p. 15).

Floods not only can cause direct loss of life and property, but also can adversely affect the use and quality of surface water, resulting in economic and environmental costs that are not apparent until the floodwaters recede. For example, floods transport large quantities of sediment and debris from eroding channels, and then deposit the material on cropland and streets and in homes, reservoirs, and stock ponds. In addition, waterfowl nesting can be disrupted when areas adjacent to lakes become flooded.

Derived from Major floods in Utah is excerpted from Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, **National Water Summary 1988-89-- Hydrologic Events and Floods and Droughts:** *U.S. Geological Survey Water-Supply Paper 2375, 591 p.*

Assessing Vulnerability by Jurisdiction

[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events

Assessing the states vulnerability to flooding in a quantitative matter proved quite problematic. Utah has limited mapped flood plains and with the exception of Salt Lake and Utah Counties floodplain maps have not yet been digitized. Using NFIP statistics provided limited utility in determining flood vulnerability. Much of Utah's flood risk is either not mapped, mapped as Zone D Indicating the flood risk is undetermined, the city or county does not participate in the NFIP, or because people in the state perceive there is not flood risk and do not believe there is a need to purchase flood insurance. Therefore, much of Utah's flood loss goes unreported. Evidence of this can be seen in figure I-11. In almost 25 years, the National Flood Insurance Program as paid out only $4.7 million dollars on 714 claims.

NFIP Flood Insurance Statistics for Utah (1/1/78-12/31/02)	
Policies in-force	2,470
Insurance in-force	$363,437,700
Premiums in-force	$1,105,027
Total losses	714
Total payments	$4,788,328.59

Figure I-11 NIFP Statistics

To determined flood vulnerability for each jurisdiction, the state's floodplain experts were assembled to provide a qualitative vulnerability assessment, classifying each county into a high, medium, or low flood vulnerability rating. Experts included the State Flood Plain Manager, State Hazard Mitigation Officer, the U.S. Army Corps of Engineers, and members of the State Hazard Mitigation Team. Classifications were based on population, in-place flood mitigation, age and accuracy of NFIP maps, dollar amounts of infrastructure values from HAZUS MH, past flood loss, and the potential for future flooding as a result of development pressure. Counties classified as having a Low hazard rating can still and often do experience flooding. This flooding is most often localized doing significant damage to a small number of structures.

High
Salt Lake
Davis
Utah
Summit
Weber
Tooele
Washington

Medium	Wasatch	Sevier
Box Elder	Uintah	Grand
Cache	Sanpete	Iron
Morgan	Carbon	
Low	Juab	Piute
Rich	Millard	Wayne
Daggett	Emery	Garfield
Duchesne	Beaver	San Juan
Kane		

Limited digital data combined with NFIP statistics, which do not adequately represent the true flood vulnerability of Utah, should not be used to underscore the flood risk in Utah. Flooding in Utah is typically localized and just under the threshold of a major disaster. For example on September 12, 2002 intense rainfall triggered multiple debris flows on Dry Mountain in Utah County. These debris flows did significant damage to the City of Santaquin and the unincorporated area of Spring Lake. There was one NFIP policy in the subdivision and fifty homes were affected. On September 9, 2003, San Juan County was rocked by fall rainstorms, which caused flooding along the San Juan River and its tributaries, causing approximately $2 million dollars in damage. Flooding caused basement damage in the spring of 2004 in Weber County when an undersized storm water ditch overflowed its banks. On April 6, 2004 heavy rains caused damage to homes along the Compton Bench areas of Farmington City. These are only some of the events, which occurred over the last two years.

Utah floods are not typical the large multi-day events seen in the Midwest or along the east coast, floods are typically localized events running out of mountain or desert canyons. Individuals feel the pain of flood loss regardless of location, those damaged by flood loss in Utah suffered equal to those flooded along the Mississippi during the 1990's. Past damage shows if FEMA used a cumulative threshold to determined the need for a Presidential declaration chances are Utah would receive one every year, not every ten as the statistics indicate

In the past Utah has received two Presidential declarations for flooding one in 1983 the other in 1984. The lack of Presidentally declared disasters speaks volumes to the nature of Utah's flood vulnerability and to the nature of Utah's "go it alone" philosophy on mitigation. Following the events of 1983-84 an enormous amount of mitigation was installed along the urban areas of the Wasatch Front, which experienced flooding. As an example, Salt Lake County started a county flood control project and pumps were installed on the Great Salt Lake. Today Utah utilizes an advanced water-monitoring network of stream gauges, SNOTEL sites, and automated stream flow gates.

Estimating Potential Losses by Jurisdiction

[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…

Due to the lack of digital floodplain maps it was virtually impossible to conducted a vulnerability analysis, which produced losses by jurisdiction based on dollars amounts of at risk infrastructure. This is something the state desperately wants to correct, and will as floodplain maps are digitized through the Floodplain Map Modernization Program, and as GIS loss estimation tools such as HAZUS MH become more advanced. At this time only two Utah counties have digitized flood plain maps Salt Lake County and Utah County, estimated losses for these counties are listed in Table I-15 and I-16. Understanding dollar losses is vital to performing cost effective mitigation further supporting Utah's number one flood related mitigation goal of modernizing the inventory of floodplain maps.

This plan incorporates and advocates the State "Map Modernization Program Business Case Plan" and the State "Map Modernization Prioritization Plan" as a solution to the abundant problems with the NFIP maps. Together these plan layout an achievable plan to modernize floodplain maps within the state of Utah. The need for updated floodplain maps was the number one issue being, consistently raised by locals throughout the PDM planning process and continues to be the top priority of the State Floodplain Management Program. This ties directly into Utah's inability to estimate flood losses by jurisdiction, because of lack of accurate digital flood maps.

Table I-15 Salt Lake County Estimated 100-Year Flood Plain Losses

City Name	City Area (Acres)	Acres in 100 Year Flood Plain	Number of Structures within 100 Year Floodplain		Population in Hazard Area
			Residential / Replacement Value	Commercial/ Annual Sales	
Alta	2,623	3	0	0	0
Bluffdale	10,543	179	11 / $5,628,290	1 / $100,000	35
Draper	14,187	293	172 / $48,378,260	38 / $22,400,000	550
Herriman	7,744	204	71 / $14,128,210	1 / $300,000	227
Holladay	3,235	43	19 / $14,681,820	25 / $9,600,000	61
Midvale	3,840	32	8 / $654,400	18 / $32,400,000	26
Murray	6,690	170	196 / $30,533,950	61 / $56,100,000	568
Riverton	8,044	361	210 / $43,393,200	11 / $7,400,000	609
Salt Lake City	70,938	2,975	459 / $66,013,850	353 / $941,800,000	1,331
Sandy	14,367	201	141 / $37,322,340	15 / $11,600,000	409
South Jordan	14,150	786	378 / $99,249,270	25 / $11,800,000	1,096
South Salt Lake	4,409	281	165 / $18,299,500	84 / $187,400,000	528
Taylorsville	6,963	141	93 / $22,173,160	2 / $900,000	307
West Jordan	20,448	717	287 / $77,460,590	96 / $153,200,000	947
West Valley	22,808	715	335 / $49,542,360	85 / $588,100,000	1,106
Un-Incorporated	304,953	56,806	861 / $234,634,650	92 / $159,100,000	2,238

Courtesy of WFRC

I-16 Utah County Estimated 100-Year Flood Plain Losses

City	County	Population	Households	Value	Employment
Alpine	Utah	2,970	693	$103,950,000	24
American Fork	Utah	1,407	354	$53,100,000	58
Cedar Hills	Utah	0	0	$0	
Genola	Utah	62	17	$2,550,000	
Highland	Utah	1,042	245	$36,750,000	
Lehi	Utah	3,020	821	$123,150,000	166
Lindon	Utah	1,737	398	$59,700,000	338

Mapleton	Utah	469	115	$17,250,000	
Orem	Utah	633	170	$25,500,000	473
Payson	Utah	1,649	441	$66,150,000	191
Pleasant Grove	Utah	173	40	$6,000,000	
Provo	Utah	8,438	2,409	$361,350,000	1388
Salem	Utah	604	186	$27,900,000	7
Saratoga Springs	Utah	451	123	$18,450,000	
Spanish Fork	Utah	1,157	298	$44,700,000	87
Springville	Utah	834	233	$34,950,000	51
Utah	Utah	1,795	492	$73,800,000	
Vineyard	Utah	48	16	$2,400,000	

Courtesy of Mountainlands AOG

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

As stated above, without digital floodplain maps it is cost prohibitive to determine which flood zone if any Utah's 5,000 plus state owned facilities are located in. A floodplain study initiated by the State Department of Facilities and Management found no critical facilities owned by the state in the 100-year flood plain. In future versions of the State Hazard Mitigation Plan, it is anticipated the state will utilize digitized floodplain maps to determine and exact dollar loss amount vulnerable to flooding for each state owned facility. However, until maps, are brought into the spatial realm of GIS it will continue to be capital intensive in terms of both financial and human to grasp both the number and dollar value of those buildings in the flood plain.

Estimating Potential Losses by State Facilities

[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

In order to estimated the potential loss Utah could face due to state owned facilities in a flood zone. To have a complete analysis the state needs a database of state owned facilities, which have been assigned a spatial location and digital flood plain maps. Utah currently has neither of these. Through the Flood Map Modernization Program Utah will be receiving digital flood plain maps. To accompany these new maps Utah will digitize the state owned facilities data set, together this will supply Utah with an accurate picture of which state owned facilities are in the flood plain and allow an estimate of potential loss. As maps are completed under the Map Modernization Program they will be incorporated in to future revisions to this mitigation plan.

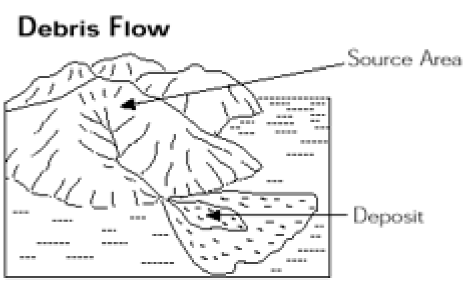
Landslides

Profiling Hazard Event

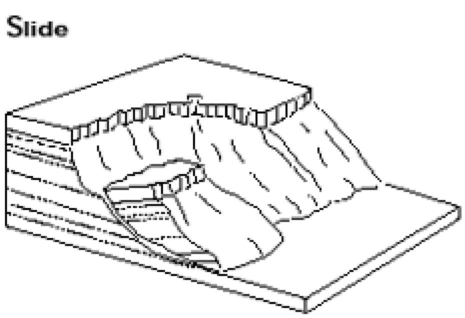
> ***The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.***

Landslides are a "down slope movement of a mass of rock, earth, or debris". Landslides, often referred to as mass wasting or slope failures, are one of the most common natural disasters. (Cruden 36). Slope failures can vary considerably in shape, rate of movement, extent, and impact on surrounding areas. Slope failures are classified by they're type of movement and type of material. The types of movement are classified as falls, slides, topples, and flows. "The types of material include rock, debris (coarse grained soil) and earth (fine grained soil)" (Eldredge 17). "Types of slope failures then are identified as rock falls, rock slides, debris flows, debris slides, and so on" (Eldredge 17). Slope failures occur because of either an increase in the driving forces (weight of slope and slope gradient) or a decrease in the resisting forces (friction, or the strength of the material making up a slope). "Geology (rock type and structure), topography (slope gradient), water content, vegetative cover, and slope aspect are important factors of slope stability" (Eldredge 18).

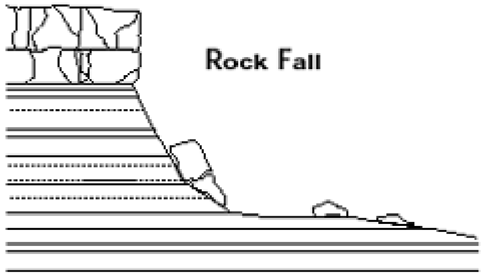
Figure I-12 Three Common Types of Landslides in Utah



Debris flows consist of sediment-water mixtures that flow down a streambed or hillside, commonly depositing sediment at canyon mouths in fan like deposits know as alluvial fans.



Slides are down slope movements of soil or rock on slopes.



Rock falls consist of rock(s) falling from a cliff or cut slope and are very common in the canyon country of southern Utah.

Conditions That Make Slopes More Susceptible to Landslides

- Discontinuities: faults, joints, bedding surfaces.
- Massive materials over soft materials.
- Orientations of dip slope: bedding planes that dip out of slope.
- Loose structure and roundness.
- Adding weight to the head of a slide such as: rain, snow, landslides, mine waste piles, buildings, leaks from pipes, sewers, and canals, construction materials fill materials.
- Ground shaking: earthquakes or vibrations.
- Increase in lateral spread caused by mechanical weathering.
- Removal of lateral support.
- Human activities: cut and fill practices, quarries, mine pits, road cuts, lowering of reservoirs.
- Removing underlying support: under cutting of banks in a river.
- Increase in pore water pressure: snow melt, rain, and irrigation.
- Loss of cohesion.

Landslide History

Nationwide, estimated losses from damaging landslides range from $1.2 to $2.4 billion annually (Schuster, 1996). In Utah, documented losses from damaging landslides in 2001 exceeded $3 million, including the costs to repair and stabilize hillsides along state and federal highway (Ashland, 2003). Total landslide dollar losses are hard to determine for past events because a standard for documenting them does not exist. Several state and local agencies track landslide losses with inconsistent formats often resulting in several different totals for a single event. The recurrent or ongoing movement at very slow rates, of some slides, results in widespread, but typically limited damage. This movement, cumulatively over several years, causes damage. Francis Ashland, of the Utah Geologic Survey discusses landslide damages in Utah as well as the difficulties of accruing accurate post movement loss numbers. His work “The Feasibility of Collecting Accurate Landslide-Loss Data in Utah, Open File Report 410” is found in appendix K of this plan.

Thistle Slide:

In 1983, the town of Thistle was destroyed by floodwaters when the Thistle landslide created a natural dam and subsequent reservoir blocking roads and rail line. The Marysvale branch line, of the railroad was never reopened, leaving a large area of central Utah without rail service. Thistle resulted in Utah's first presidential disaster declaration and became the most costly landslide in United States history. Three reports have been issued estimating the cost of the landslide between $200 million and $337 million dollars.

<u>Heather Drive Landslide:</u>
In 2001 this landslide destroyed three houses and forced the relocation of three others. Total dollar losses for this event have been estimated various sources between $519,800 and $1,092,000.

<u>Santaquin Mollie Fire Debris Flow:</u>
In August of 2001, the 8,000+ acre Mollie Fire burned an area of the Wasatch Range known as Dry Mountain above the city of Santaquin. The bench development area of Santaquin City is located not more than 50 yards from the edge of the fire perimeter on an alluvial fan. The Mollie wildfire, caused watershed damaged elevated the debris flow risk.

At approximately 6:45 p.m. on Thursday, September 12, 2002, after nearly a week of intense thunderstorms, the charred earth of the ironically named Dry Mountain produced 10 debris flows. These flows did major damage to several houses and resulted in significant clean up costs.

<u>Buckley Draw—Springville Fire:</u>
The Springville fire started on June 30, 2002 at 7:19 p.m. and burned a total of 2,207 acres above dozens of homes. This burned area heightened the debris flow risk to those homes on the alluvial fans below. At the April 29, 2003 neighborhood meeting, the debris flows in Santaquin were contrasted with the conditions at the Buckley Draw. Plans for trench construction were discussed. A flag notification system and evacuation plan was put in place. A web link with updated hazard information, a phone 'hot line' with an updated message, and a notification procedure alerting the Neighborhood Chair of any changes in the hazard level were implemented. A practice evacuation drill was held on Saturday, May 10, 2003.

The 1,500 feet long trench/deflection dike was completed on July 28, 2003, by Provo City in conjunction with the NRCS and their Emergency Watershed Protection program. At approximately 3:00 a.m. on September 10, 2003, four separate debris flows were triggered. The newly finished trench routed the second largest flow. The trench finished "in a nick of time" worked as designed preventing property loss and potentially life loss. It is difficult to predict total amount of damage prevented by the trench, but at a minimum the deflection dike prevented damage equal to its construction cost. The spreader fences in the debris runout field distributed the runoff materials and completely contained this debris flow.

Assessing Vulnerability by Jurisdiction

> ***[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with***

Many factors contribute to overall landslides vulnerability; including local weather, soil moisture, duration and intensity of precipitation, wildfire history, and development pressure. County rankings below were accomplished by summing the total acreage of landslides within incorporated cities and towns. This GIS analysis used a digital landslide map compiled by Kimm Harty of landslides both historically active (1847 to present) and prehistoric landslides. This data set also included lateral spreads and shallow landslides (debris flows). Cities and towns as designated by the 2000 Census, were used to represent incorporated areas, this was done because of a large amount of land in Utah is mountainous and contains numerous landslides, but these landslides pose very little risk. Federal land management agencies have jurisdiction over the majority of unincorporated land in Utah's rural counties, thus most contain very little if any vulnerable structures or populations. City and town totals were also used because the majority of the built structures in Utah reside within an incorporated town or city.

This list represents the total acreage of city land in each county with a mapped landslide. So although this is a good indictor of landslide vulnerability total vulnerability depends on how this land is regulated. Large portions of the mapped landslides, utilized in this analysis, were on lands often valued for development. As development pressure mounts total vulnerability will be a function of how cities and counties manage the development on sensitive lands such as those with a known landslide risk.

1. Weber*
2. Davis*
3. Piute
4. Utah*
5. Cache
6. Beaver
7. Wasatch*
8. Summit*
9. Sevier
10. Salt Lake*
11. Wayne
12. Duchesne
13. Garfield
14. Carbon
15. Emery
16. Juab
17. Sanpete
18. Iron*
19. Grand
20. Tooele
21. Millard
22. Uintah
23. Kane
24. San Juan
25. Daggett
26. Rich
27. Washington*(**)
28. Box Elder
29. Morgan

The GIS layer utilized to complete the county ranking corresponds with a map compiled by Kimm M. Harty with the Utah Geological and Mineral Survey in 1991.
*Areas where recent landslide losses have occurred.
** Landslides in Washington County have not been fully digitized.

Given the number of variables in predicating landslides Francis Ashland qualitatively identified the following areas of the state as having the highest risk to landslides.
Layton City
Bountiful City
Draper City
Provo City
North Salt Lake
Spanish Fork Canyon transportation/lifeline corridor

Figure LS-2 Landslide scarp City Creek Canyon, 1998 Courtesy of UGS.

Estimating Potential Losses by Jurisdiction

[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…

Potential landslide losses for each jurisdiction in the state were compiled as part of the seven Pre-Disaster Mitigation plans completed by the seven Associations of Government. These plans are found in appendix I and are on file with the State Division of Emergency Services. The plans determined landslide vulnerability to homes, businesses, roads, power lines, and rail lines.

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

A state owned facilities data set was created by pulling state owned facilities out of the June 2002 Equifax Business dataset, based on OSHA SIC codes. The new state owned facilities data set was overlaid on top of landslide susceptibility map created by Kimm Harty. Using the "select by theme" feature in ArcView 3.x all of the vulnerable structures intersecting the landslide susceptibility areas were selected. The selected items were then saved as a theme, whose table was joined with the county FIPS codes to determine which structures are in each county.

Table 17 Total Number of State Owned Facilities in Landslide Susceptibility Areas

County	Total Vulnerable Structures
Beaver	96

Box Elder	0
Cache	0
Carbon	0
Daggett	5
Davis	42
Duchesne	0
Emery	0
Garfield	0
Grand	0
Iron	9
Juab	0
Kane	0
Millard	0
Morgan	0
Piute	0
Rich	1
Salt Lake	1
San Juan	5
Sanpete	0
Sevier	2
Summit	4
Tooele	0
Uintah	0
Utah	3
Wasatch	0
Washington	0
Wayne	0
Weber	96
Total	**264.00**

Estimating Potential Losses by State Facilities

[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

Estimating values for state owned facilities in landslide susceptibility areas was determined by multiplying the average insured value of state owned facilities in each county by the total number of vulnerable building in each county. Average insured value of state facilities per county was provided by State Risk Management a section of the State Department of Administrative Services.

Table 18 Total Insured Value of State Owned Facilities in Landslide Susceptibility Areas

County	Total Vulnerable Structures	Estimated Insured Value
Beaver	96	$84,692,160.00

Box Elder	0	0
Cache	0	0
Carbon	0	0
Daggett	5	$1,569,475.15
Davis	42	$168,103,333.44
Duchesne	0	0
Emery	0	0
Garfield	0	0
Grand	0	0
Iron	9	$15,164,964.09
Juab	0	0
Kane	0	0
Millard	0	0
Morgan	0	0
Piute	0	0
Rich	1	$323,843.23
Salt Lake	1	$3,374,600.94
San Juan	5	$4,295,013.75
Sanpete	0	0
Sevier	2	$2,026,364.40
Summit	4	$5,906,036.72
Tooele	0	0
Uintah	0	0
Utah	3	$9,697,989.27
Wasatch	0	0
Washington	0	0
Wayne	0	0
Weber	96	$316,483,069.44
Total	**264.00**	**$611,636,850.43**

Severe Weather

Profiling Hazard Event

The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.

For the purpose of this mitigation plan the term severe weather is used to represent a broad range of weather phenomena which affect Utah:

- Downbursts,
- Lightening,
- Heavy snowstorms,
- Blizzards,
- Avalanches,
- Hail, and
- Tornados.

1999 Salt Lake Tornado

Severe weather event are the most deadly type of natural disaster in Utah. More people have died in avalanches in Utah than by any other natural hazard. Between 1958 and 2003 avalanches killed 70 people, accounting for 47% of all deaths in Utah attributed to natural disasters. Since 1950, lightening has killed 57 people and injured another 139 accounting for 36 % of deaths related to natural disasters.

Downbursts

A downburst is a severe localized wind, blasting from a thunderstorm. The destruction of property may be devastating depending on the size and location of these events. Microbursts, which cover and area less than 2.5 miles in diameter, and macrobursts, which cover an area with a diameter larger 2.5 miles also have a significant impact on property

Lightening

During the development of a thunderstorm, the rapidly rising air within the cloud, combined with the movement of the precipitation within the cloud, causes electrical charges to build. Generally, positive charges build up near the top of the cloud, while negative charges build up near the bottom. Normally, the earth's surface has a slight negative charge. However, as the negative charges build up near the base of the cloud, the ground beneath the cloud and the area surrounding the cloud becomes positively charged. As the cloud moves, these induced positive charges on the ground follow the cloud like a shadow. Lightening is a giant spark of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. In the initial stages of development, air acts as an insulator between the positive and negative charges. When the potential between the positive and negative charges becomes to great, there is a discharge of electricity that we know as lightning.

Lightening deaths by county from 1950 to present in alphabetical order.

Cache	2	Iron	1	Summit	6
Carbon	2	Juab	2	Tooele	2
Daggett	1	Morgan	1	Uintah	2
Davis	1	Piute	1	Utah	2
Duchesne	4	Rich	1	Wasatch	2
Emery	1	Salt Lake	7	Wayne	1
Garfield	3	San Juan	6	Weber	2
Grand	4	Sanpete	3	**Total**	**57**

Lightening related injuries by county from1950 to present in alphabetical order.

Beaver	2	Grand	3	Tooele	10
Cache	7	Morgan	2	Uintah	3
Carbon	4	Piute	1	Utah	12
Daggett	1	Salt Lake	41	Wasatch	3
Davis	3	San Juan	3	Washington	2
Duchesne	7	Sanpete	1	Wayne	1
Emery	7	Sevier	1	Weber	4
Garfield	6	Summit	13		
Total	**139**				

Heavy Snowstorms

A severe winter storm deposits four or more inches of snow during a 12-hour period or six inches of snow during a 24-hour period. According to the official definition given by the U.S. Weather Service, the winds must exceed 35 miles per hour and the temperature must drop to 20° F or lower. All winter storms make driving extremely dangerous.

Blizzards

A blizzard is a snowstorm with sustained winds of 40 miles per hour (mph) or more or gusting winds up to at least 50 mph with heavy falling or blowing snow, persisting for one hour or more, temperatures of ten degrees Fahrenheit or colder and potentially life-threatening travel conditions. The definition includes the conditions under which dry snow, which has previously fallen, is whipped into the air and creates a diminution of visual range.

Avalanches

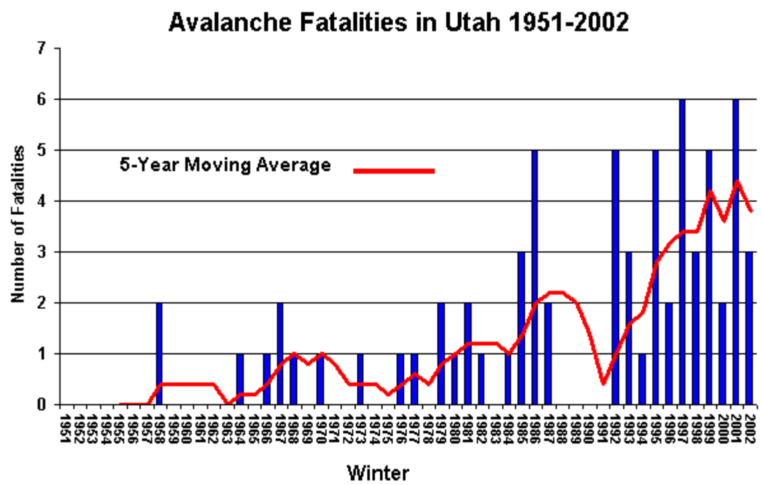
Avalanches are a rapid down-slope movement of snow, ice, and debris. Snow avalanches are a significant mountain hazard in Utah, and nationally account for more deaths each year than earthquakes. Avalanches are the result of snow accumulation on a step slope and can be triggered by ground shaking, sound, or a person. Avalanches consist of a starting zone, a track, and a run-out zone. The starting zone is where the ice or snow breaks loose and starts to slide. The track is the grade or channel down which an avalanche travels. The run-out zone is where an avalanche stops and deposits the snow.

The two main factors affecting avalanche activity include weather and terrain, large frequent storms combined with steep slopes result in avalanche danger. Additional

factors that contributing to slope stability are amount of snow, rate of accumulation, moisture content, snow crystal types and the wind speed and direction. In Utah, the months of January through April have the highest avalanche risk.
Topography plays a vital role avalanche dynamics. Slope angles between 30 to 45 degrees are optimum for avalanches with 38 degrees being the bulls-eye. Slopes with and angle above 45 degrees continually sluff eliminating large accumulation. The risk of avalanches decreases on slope angles below 30 degrees.

Types of Avalanches Common in Utah

Dry or slab avalanches: occur when a cohesive slab of snow fractures as a unit and slides on top of weaker snow, breaking apart as it slides. Slab avalanches occur when additional weight is added quickly to the snow pack, overloading a buried weaker layer. Dry snow avalanches usually travel between 60-80 miles per hour, reaching this speed within 5 seconds of the fracture, resulting in the deadliest form of snow avalanche.



Wet avalanches: occur when percolating water dissolves the bonds between the snow grains in a pre-existing snow pack, this decrease the strength of the buried weak layer. Strong sun or warm temperatures can melt the snow and create wet avalanches. Wet avalanches usually travel about 20 miles per hour.

Table I-19 Avalanche Fatalities in Utah 1958-2003 by Activity

	Skier	Climber	Snowboarder	Snowmobiler	Recreation	Worker	Resident
1958 Season - Present	35	5	7	9	8	5	1
Past 10 Seasons	17	3	6	9	5	1	1
Past 5 Seasons	5	3	6	7	5	0	0

* Courtesy of the Utah Avalanche Forecast Center, Snow and Avalanches in Utah Annual Report 2002-2003

Hail Storms

Hailstones are large pieces of ice that fall from powerful thunderstorms. Hail forms when strong updrafts within, the convection cell of a cumulonimbus cloud carries water droplets upward causing them to freeze. Once the droplet freezes, it collides with other liquid droplets that freeze on contact. These rise and fall cycles continue until the hailstone becomes too heavy and falls from the cloud.

<u>Tornados</u>

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. Tornados often occur at the edge of an updraft or within the air coming down from a thunderstorm. Tornadoes can have wind speeds of 250 miles per hour or more, causing a damage zone of 50 miles in length and 1 mile wide. Most tornados have winds less than 112 miles per hour and zones of damage less than 100 feet wide.

Number of observed tornadoes by county in alphabetical order

		Iron	5	Summit	0
Beaver	4	Juab	1	Tooele	5
Box Elder	9	Kane	0	Uintah	5
Cache	4	Millard	3	Utah	8
Carbon	1	Morgan	1	Wasatch	0
Daggett	1	Piute	1	Washington	2
Davis	10	Rich	2	Wayne	7
Duchesne	3	Salt Lake	15	Weber	6
Emery	7	San Juan	0	**Total**	**119***
Garfield	1	Sanpete	9		
Grand	5	Sevier	4		

* Three of the above tornadoes were counted twice because they traveled across county borders. Courtesy of the National Weather Services.

<u>Number of injuries</u>

2 people on July 8, 1989
1 male on August 14, 1968
1 female on April 19, 1970
1 male on April 23, 1990
2 people on June 2, 1993

<u>Number of deaths</u>

1 male on August 11, 1999
1 female was killed on July 6, 1884.

Plastic cup logged in storefront sign as a result of the August 11, 1999 tornado.

<u>Stated monetary damage by tornadoes:</u>

1,200	June 1, 1955
5,000	June 16, 1955
20,000	June 3, 1963
2,000	August 28, 1964
10,000	April 17, 1966
15,000	November 2, 1967
50,000	August 14, 1968
5,000	May 29, 1987

3,000	May29, 1988
25,000	September 17, 1989
500	March 23, 2990
1,500	September 23, 2992
8,000	April 4, 1993
50,000	May 3, 1993
15,000	June 2, 1993
500,000	May 29, 1996
170,000,000+	August 11, 1999
100,000+	September 3, 1999
100,000	May 25, 2000
2,000,000	September 8, 2002
100,000	March 8, 2002
173,011,200+	total

1999 Salt Lake Tornado damage

Utah's strongest Tornadoes

F2	January 22, 1943	Young Ward
F2	June 3, 1963	Bountiful
F2	November 2, 1967	Emery
F2	August 14, 1968	West Weber
F2	May 29, 1987	Lewiston
F3	August 11, 1993	Uinta Mountains
F2	August 11, 1999	Salt Lake City
F2	September 8, 2002	Manti

Waterspout

Waterspouts are simply tornadoes that form over warm water. This typically occurs in Utah during a cold fall or late winter storms.

Scale

Tornadoes are classified by wind damage using the Fujita Scale. The National Weather Service has used the Fujita Scale since 1973. This scale uses numbers from 0 through 5 with higher numbers assigned based on the amount and type of wind damage.

Table I-20 Fujita Scale

Category F0	Gale tornado (40-72 mph)	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1	Moderate tornado (73-112 mph)	Moderate damage. The lowers limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
Category F2	Significant tornado (113-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3	Severe tornado	Severe damage. Roofs and some walls torn

	(158-206 mph)	off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
Category F4	Devastating tornado (207-260 mph)	Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5	Incredible tornado (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobiles-size missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

Assessing Vulnerability by Jurisdiction

[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Assessing vulnerability and determining which counties if any are more vulnerable to the hazards grouped as severe weather is very problematic. Using the principle of the past being the key to the future is somewhat useful. For example, Salt Lake County has had the largest number of deaths attributed to lightening, one could assume, that this trend will continue into the future. Yet, this is not a certainty. Know one knows were the next bolt of lightening will strike. Additionally, Salt Lake County contains the states largest population, which has little to do with the higher number of fatalities. San Juan County has the next largest number of fatalities due to lightening and is one of Utah's least populated counties. 23 of Utah's 29 counties have experienced a lightening death, 25 of 29 counties have experienced a tornado, and all 29 counties have experienced hailstorms, blizzard, heavy snow, and downbursts.

Estimating Potential Losses by Jurisdiction

[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…

It is virtually impossible to estimate potential losses by jurisdiction for the phenomena grouped into severe weather. Several factors limit determining potential losses they include:

- Lack of research on location
- Most hazards are tied to weather and can not be predicted with a location
- Limited GIS data available for the single map able hazards of avalanche,
- The entire state shares the nearly the same risk

Severe weather hazards can do extensive damage to property and crops, but with the exception of avalanche can occur at almost any time in any area of the state.

Avalanches typically occur on snow-loaded slopes between 30 and 45 degrees with 38 degrees being the optimum slope angle for avalanches. Avalanches typically do very little property damage as the often occur in forested or alpine areas outside of the human built environment. Yet, numerous residents of the state are still killed each year by avalanches, and the cost of search and rescue or body recovery is burdening county governments, typically tasked with the search and rescue effort.

When considering dollar losses as a function of potential losses and thus jurisdictional vulnerability, a key variable is the value of the human built environment and population. Therefore, the more populous counties along the Wasatch Front would rise to the top, those counties being Salt Lake, Davis, Weber, Tooele, and Utah.

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

With the exception of avalanche and tornado these hazards typically cause very little damage to state owned facilities. The August 1999 tornado in Salt Lake City tracked just east of the state capitol doing extensive damage to several of the state owned buildings in the capitol complex, breaking windows and downing trees. All of the state owned facilities share an equal risk of being struck by a tornado, or having damage done to them by a severe weather. As with most hazards building codes adopted of late, incorporating advances in science and engineering, have resulted in newer buildings being more resistant to the forces of severe weather.

Very few building exist in known avalanche slide paths and extensive research has found no case were a state owned facility was damaged by an avalanche. Avalanches do periodically block mountain roads limiting access to ski resorts and detouring critical transportation routes.

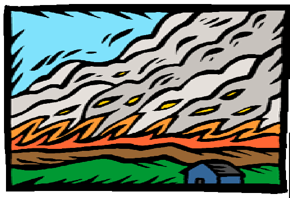
Estimating Potential Losses by State Facilities

[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

As the State of Utah remains vulnerable to severe weather, state-owned facilities are equally at risk to incur damages due to hazard occurrences. However, the state's resources, both monetary and fixed assets, depend heavily upon these facilities and there continuity. Utah has a total of 5,228 state owned facilities with an insured value of 11.8 billion dollars. To some extent all of these state owned facilities are vulnerable to severe weather. The extent to which this risk is present has to do with location, construction type, height, and age. Table I-21, is a list of all state owned facilities in each county and their total insured value.

Table I-21 Total Number of State Owned Facilities per County and Their Insured Value

County Name	Total # of State Owned Buildings	Total insured Value
Beaver	45	$39,699,450.00
Box Elder	122	$211,708,229.00
Cache	516	$1,002,633,308.00
Carbon	136	$145,275,708.00
Daggett	29	$9,102,956.00
Davis	210	$840,516,668.00
Duchesne	93	$102,289,698.00
Emery	85	$73,636,967.00
Garfield	60	$36,643,566.00
Grand	66	$38,187,807.00
Iron	184	$310,039,266.00
Juab	62	$47,790,128.00
Kane	54	$36,057,015.00
Millard	79	$87,441,289.00
Morgan	58	$30,834,955.00
Piute	25	$11,895,352.00
Rich	40	412,953,729.00
Salt Lake	1,495	$5,045,028,405.00
San Juan	106	$91,054,292.00
Sanpete	162	$217,449,191.00
Sevier	110	$111,450,042.00
Summit	112	$165,369,028.00
Tooele	87	$160,620,627.00
Uintah	113	$118,046,950.00
Utah	444	$1,435,302,412.00
Wasatch	140	$78,873,511.00
Washington	151	$380,991,528.00
Wayne	35	$10,205,255.00
Weber	298	$982,416,195.00



Wildfire

Profiling Hazards

The risk assessment shall include an] overview of the location of all natural hazards that can affect the State, including information on previous occurrences of hazard events as well as the probability of future hazard events, using maps where appropriate.

A wildfire is an uncontrolled fire spreading through vegetative fuel often exposing or consuming structures. Wildfires often begin unnoticed and spread quickly and are usually sighted by dense smoke. Wildfires are placed into two classifications <u>Wildland</u> and <u>Urban-Wildland Interface</u>. Wildland fires are those occurring in an area where development is essentially nonexistent, except for roads, railroads, or power lines. Urban-Wildland Interface fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels. URWIN areas are divided into three subclasses:

- **Occluded interface**
  Occluded interface are those areas of wildlands within an urban area for example a park bordered by urban development such as homes.

- **Intermixed**
  Mixed or intermixed interface areas contain structures scattered throughout rural areas covered predominately by native flammable vegetation.

- **Classic**
  Classic interface areas are those areas where homes press against wildland vegetation along a broad front.

When discussing wildfires it is important to remember that fires are part of a natural process and are needed to maintain a healthy ecosystem. When most of America was wilderness, wildfires burned 10 times the land that is consumed today. Yet, research shows forests were much healthier and hardier then. Wildfire is a natural part of forest ecosystems and is in fact, as necessary as water or sun. Fires cleanse and regenerate forests, giving new life to soil, and providing a new canvas for biodiversity to paint a new picture. Most all forest ecosystem types evolved with fire, and some trees, like the lodgepole pine, depend on the heat of fire to open their seed cones. A study conducted in 1995 found that of 146 threatened and endangered species of plants around the country, 135 benefited from wildland fire.

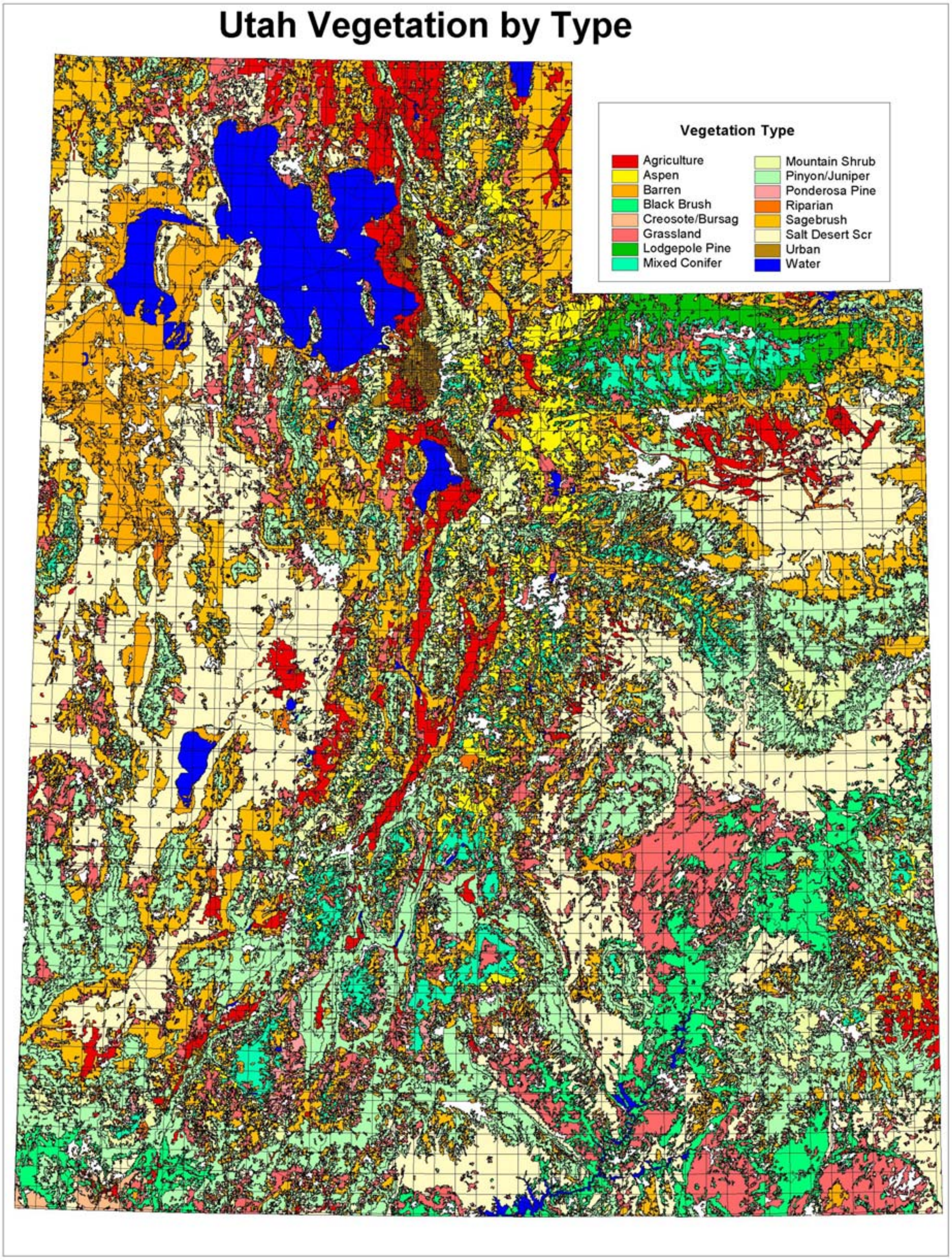
Three basic elements are needed for a fire to occur (1) a heat source (2) oxygen and (3) fuel. Two of the three sources are readily available throughout Utah. Major ignition sources for wildfire are lightning and human causes such as arson, recreational activities, burning debris, and carelessness with fireworks. On average, 65 percent of all wild fires started in Utah can be attributed to human activities. Once a wildfire has started, vegetation, topography and weather are all conditions having an affect wildfire behavior.

<u>Vegetation Within Utah as it Relates to Wildfire</u>

Fuels within Utah are generally conducive to high rates of spread, represented by National Fire Danger Rating System fuel models "L", "K", and "C". Vegetation in with in Utah is broken into the following classifications based on fire hazard potential.

Table I-22 State Vegetation Types Classified by Hazard Rating

Vegetation Types	Description	Hazard Rating
Spruce/Fir, Mountain fir, Spruce Fir/Mountain Shrub, Mountain Fir/Mountain Shrub, Conifer/Aspen, Lodgepole Pine, Juniper, Pinyon/Juniper, Pinyon	High resistance to control, extreme intensity levels resulting in almost complete combustion of vegetation and possible damage to soils and seed sources depending on slope, rates of spread, wind speed and fuel loading.	EXTREME
Mountain Mahogany, Oak, Maple, Mountain Shrub, Sagebrush, Sagebrush/Perennial Grass, Salt Desert Scrub, Black Brush, Creosote/Bursage, Grease Wood, Ponderosa Pine/Mountain Shrub.	Moderate to high resistance to control, high to moderate intensity levels resulting in high to moderate damage to resources depending on slope, rates of spread, wind speed, and fuel loading.	HIGH
Ponderosa Pine, Grassland, Alpine, Dry Meadow, Desert Grassland	Moderate to low resistance to control, fire intensity levels would generally be low with moderate damage to resource values depending on slope, rates of spread, wind speed, fuel loading.	MODERATE
Aspen, Mountain Riparian, Lowland Riparian, Wet Meadow, Wetland	Low to moderate resistance to control, fire intensity levels would generally be low, little threat to human values and potentially beneficial to resource values depending on slope, rates of spread, wind speed, and fuel loading.	LOW


Utah Vegetation by Type
Vegetation Type
Agriculture
Aspen
Barren
Black Brush
Creosote/Bursag
Grassland
Lodgepole Pine
Mixed Conifer
Mountain Shrub
Pinyon/Juniper
Ponderosa Pine
Riparian
Sagebrush
Salt Desert Scr
Urban
Water

Map I-5

Development and Wildfire

Throughout the United States it is more and more common to see homes and other types of structures in wildland environments. This trend is greatly expanding wildland/urban interface areas, continually placing more and more structures in areas with large amounts of natural vegetation. Because of their location, these structures are extremely vulnerable to fire should a wildland fire occur in the surrounding area. Expansion into wildland areas also places wildland areas at risk, by increasing the number of ignition sources. The importance these wild areas have continues to grow with each passing year. The population of the Wasatch Front depends on water from our mountains and a wildfire can greatly impact the watershed.

Wildfire is a natural part of the ecosystems in Utah. Many of the grass, brush and tree species found in Utah have evolved with fire. Many of Utah's urban/wildland interface areas are located in our most fire prone wildland fuels. Generally, these fuels are found on drier, lower elevation sites, often very desirable for real estate development.

Families are moving into the Utah's countryside, just like they are all over the United States. They are building homes and associated buildings all through Utah's rural areas. People who live in urban areas want to "get away" from it all, even if it is only for the weekend. Developers are busy meeting their needs via summer home developments, recreational developments and other means. Use of fire prone wildland areas for homes and major recreational facilities create various threats: loss of life, homes, personal possessions, and natural resources.

Wildfire History

In 2003, Utah's most current fire season, Utah was lucky. Early spring rains promoted grass growth. Grasses dry out prior to timber and ignite quite easy. This coupled with years of drought and high mortality rates in low elevation timber and shrubs made for prime fire conditions. Even though the 2003 fire season had 635, which burned 115,798 acres things could have been much worse.

2002, was a record year in terms of numbers of wildfires and the cost of wildfire suppression. This is largely a result of the extensive drought in Utah and adjacent states. Fortunately, there have been no serious injuries or fatalities to firefighters or residents of URWIN communities. Utah Forestry Fire and State Lands UFF&SL reports that from January to August 2002, more than 613 fires burned more than 265,902 acres. Suppression costs incurred by the state were near $10 million dollars. Only five states in the nation burned more acreage in 2002 than Utah. Table I-23, details the total number of fires that have occurred in Utah since 1985, number of acres burned, and the total cost to the state of suppressing these fires.

Table I-23 Wildfire History 1985 to 2003

Year	Number of Fires	Acres Burned	Suppression Fund	Total State Cost
1985	443	47,242	Pre-Fund	

Year	Number of Fires	Acres Burned	Suppression Fund	Total State Cost
1986	457	62,042	Pre-Fund	
1987	490	63,648	Pre-Fund	
1988	605	30,819	Pre-Fund	
1989	482	46,617	Pre-Fund	
1990	415	30,093	Pre-Fund	
1991	300	12,029	Pre-Fund	$2,041,369
1992	499	40,025	Pre-Fund	$2,106,927
1993	262	13,949	Pre-Fund	$1,371,793
1994	703	165,670	Pre-Fund	$3,057,815
1995	579	88,139	Pre-Fund	$2,234,507
1996	732	519,669	Pre-Fund	$6,281,902
1997	391	27,665	Pre-Fund	$4,610,890
1998	495	80,058	$237,649	$2,089,295
1999	735	133,353	$659,704	$4,257,522
2000	841	101,924	$1,192,052	$5,268,459
2001	835	94,632	$2,609,010	$5,359,422
2002	613	265,902	$7,176,203	$9,544,574
2003	635	115,798		

Wild fire Statistics courtesy of Utah Forestry, Fire, and State Lands

Between 1984 and 2001 Utah had 9,385 fires of those 53 burned more than 5,000 acres. Listed below are those fires burning more than 5,000 acres. From 1999 to present the state has received federal assistance through the Fire Management Assistance Grant Program FMAGP or Fire Suppression Assistance Grant Program FSA for three wildfires the Mollie wildfire, Mustang Wildfire, and Causey Wildfire. The total federal fire suppression assistance received for the Mollie ($53,687.00) and Mustang wildfires ($282,119.04) was $335,806.04.

Ten Mile
Catle Rock
Topliff
Tekoi
West Mona
Pony Road
Rose Ranch South
Sand Mountain
Railroad Fire (61,009 acres)
Flat Fire
Hogup
Ripple Valley
Dog Valley Wash
Davis Knolls
Milford Bench
Golden Spike
Honey Boy
Indian Reservoir

Round Top
Milford Pass
Fool Creek
Negro Mag
Big Hollow Complex
Wide Canyon
Cedar Packetts Wash
Diamond Peak
North Stansbury Complex
Hansel Valley Mt
Ox Valley-Central
Meadow
Camp Williams
Johnson Canyon
Quincy
Uinta Flats
Sage Valley
Dry Canyon II
Sarah

Fort Ranch
Lava Ridge
Affleck Park
Davis Complex
Desert Mtn
Soldier Pass
Turkey
Antelope Island #2
Hansel Mt-Rattlesnake
Magatsu Complex
Cunningham
Black Rock
Mollie
Beef Hollow
Fort Ranch (35,600 acres)
Mustang

Assessing Vulnerability by Jurisdiction

> ***[The risk assessment shall include] an overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments... The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…***

Geographic data mapped on the following pages was developed by the US Department of Interior, Bureau of Land Management during March of 2000. It assess wildland fire hazard based on a combination of accumulated values including population density, fire hazard potential and past fire occurrence density. DES simplified the BLM ratings, categorizing them into one of five ratings very low, low, moderate, high, and extreme. Using the Geoprocessing extension within Arc View data for individual counties was clipped from state and queried in ArcView allowing calculations of acreage to be made.

Table I-24 County Wildfire Vulnerability

County Name	Acres of Extreme	Acres of High	Acres of Moderate	Acres of Low/Very Low
Beaver	15	130,088	576,741	951,693
Box Elder	18,143	31,684	139,114	4,116,806
Cache	965	28,076	96,335	624,061
Carbon	3,617	52,536	311,109	581,946
Daggett		67,692	204,401	189,791
Davis	933	17,606	31,088	357,372
Duchesne		10,842	569,861	1,496,416
Emery		13,363	299,881	2,612,917
Garfield	3,221	80,346	844,045	2,404,200
Grand	2,187	102,442	550,666	1,707,455
Iron	22,711	118,431	723,186	1,249,852
Juab	85	160,430	391,656	1,629,077
Kane	26	113,350	535,065	1,980,100
Millard		105,081	307,482	3,956,751
Morgan	2,301	13,650	48,613	325,762
Piute		2,638	191,489	295,296
Rich		2,410	9,971	681,892
Salt Lake	3,254	46,836	58,171	407,856
San Juan	12,186	273,592	829,697	3,958,281
Sanpete		25,521	221,920	777,393
Sevier	11,705	107,647	336,698	772,398
Summit	4,380	43,755	331,454	823,473
Tooele	3,685	228,395	461,334	3,969,466
Uintah		74,927	631,257	2,177,548
Utah	30,549	164,302	307,283	866,813
Wasatch	1,653	47,125	113,867	610,478
Washington	6,115	213,726	598,488	738,083
Wayne			125,150	1,450,008
Weber	5,430	28,709	35,506	351,883

Estimating Potential Losses by Jurisdiction

[The risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments…

As part of the Multi-Jurisdictional Mitigation plans completed by the seven Associations of Government, city-by-city potential wildfire loss totals were compiled. Electronic Appendix I, contains all seven AOG PDM plans, please review these for a detailed look at city-by-city loss. The potential exists in Utah for fires to cause significant damage to homes and other built infrastructure, to this point Utah has escaped the large devastating wildfires seen by our neighboring states. Yet, fire suppression alone, has become an ongoing and ever increasing cost to state taxpayers.

The ranking below of counties utilizes a total of all high and extreme wildfire risk acreage for all of the cities and town in each county. Because incorporated areas typically house the majority of the human build infrastructure only those areas were summed. This method eliminates the large amount of wildfire acreage classified as extreme or high from the ranking method.

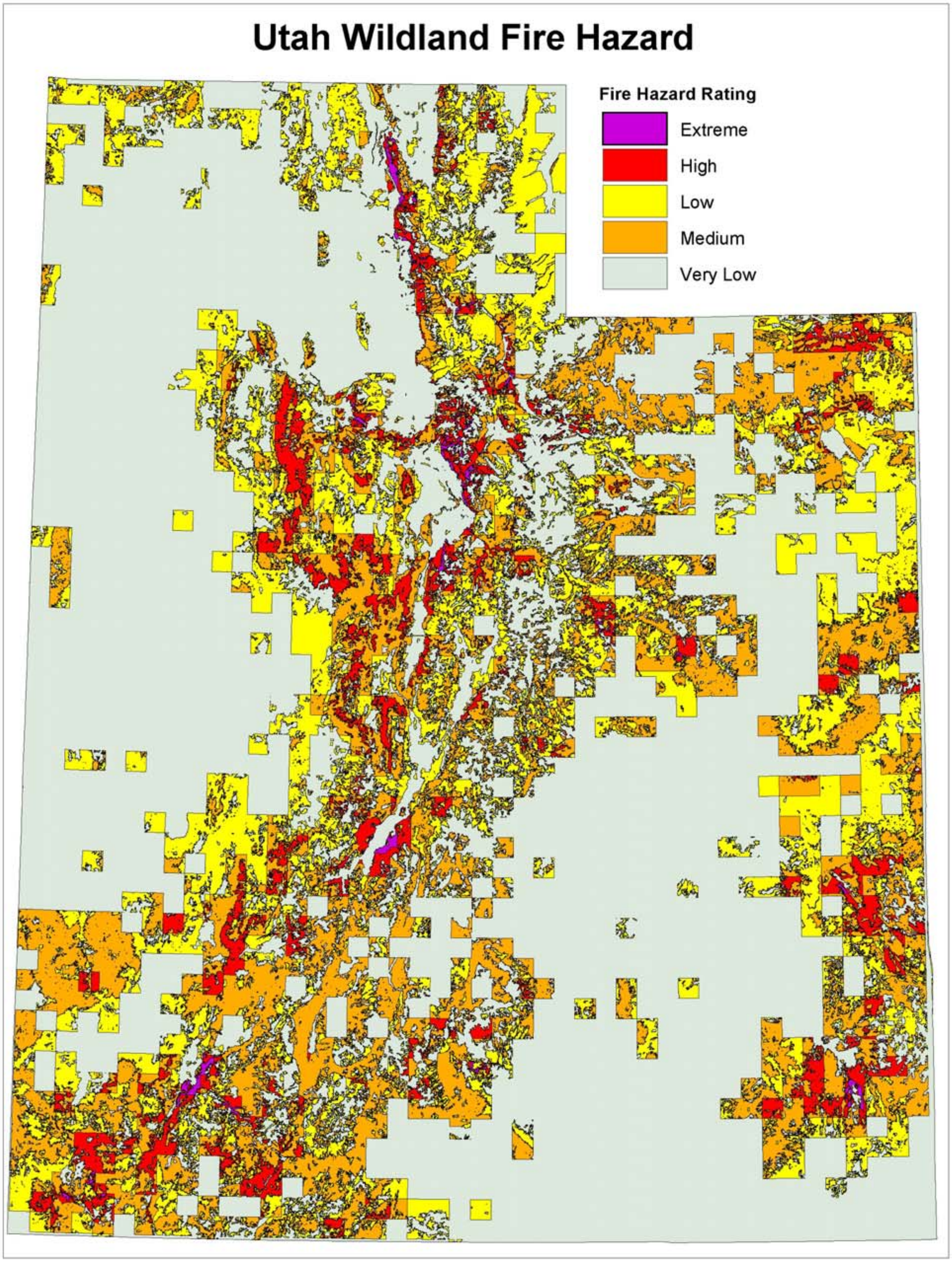
1. Washington
2. Utah
3. Salt Lake
4. San Juan
5. Summit
6. Box Elder
7. Kane
8. Iron
9. Carbon
10. Cache
11. Weber
12. Davis
13. Tooele
14. Garfield
15. Sevier
16. Grand
17. Juab
18. Emery
19. Wasatch
20. Beaver
21. Morgan
22. Rich
23. Sanpete
24. Uintah
25. Daggett
26. Piute
27. Duchesne
28. Wayne
29. Millard

Wildfire Loss Calculations

Calculating structural damage, economic loss, and deaths due to wildfire is difficult as no loss estimation tables or curves exist. FEMA publication 386-2 State and Local Mitigation Planning how-to guide Understanding Your Risks identifying hazards and estimating losses states the following under the determine the extent of damage from wildfires section:

- No loss estimation tables for wildfires
- No standard loss estimation model or table for wildfire damaged content
- No standard displacement time or functional downtime tables for wildfire
- No death or injury curves for wildfires.

Mapping was compiled to illustrate the location of each counties wildfire risk, utilizing the state wildfire risk assessment data (Maps WF-2 through WF-31). This is the same data used in the vulnerability analysis in this plan as well as in the multi-jurisdictional PDM plans assembled by the seven AOG.


Utah Wildland Fire Hazard
Fire Hazard Rating
Extreme
High
Low
Medium
Very Low

Map I-6

Assessing Vulnerability by State Facilities

[The risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in …the State risk assessment. …State owned critical or operated facilities located in the identified hazard areas shall also be addressed…

A state owned facilities data set was created by pulling state owned facilities out of the June 2002 Equifax Business dataset, based on OSHA SIC codes. The new state owned facilities data set was overlaid on top of a state wildfire risk map. The state wildfire risk map was produced as a result of the State Wide Fire Risk Assessment. Using the "select by theme" feature in ArcView 3.x all of the vulnerable structures intersecting the landslide susceptibility areas were selected. The selected items were then saved as a theme, whose table was joined with the county FIPS codes to determine which structures are in each county.

Table I-25 Total Number of State Owned Facilities in Wildfire Risk Areas

County	Total Vulnerable Structures
Beaver	4
Box Elder	1
Cache	0
Carbon	11
Daggett	7
Davis	3
Duchesne	21
Emery	8
Garfield	5
Grand	6
Iron	8
Juab	3
Kane	3
Millard	7
Morgan	0
Piute	0
Rich	2
Salt Lake	4
San Juan	19
Sanpete	2
Sevier	2
Summit	2
Tooele	7
Uintah	0
Utah	4
Wasatch	3
Washington	7
Wayne	0
Weber	4
Total	**143.00**

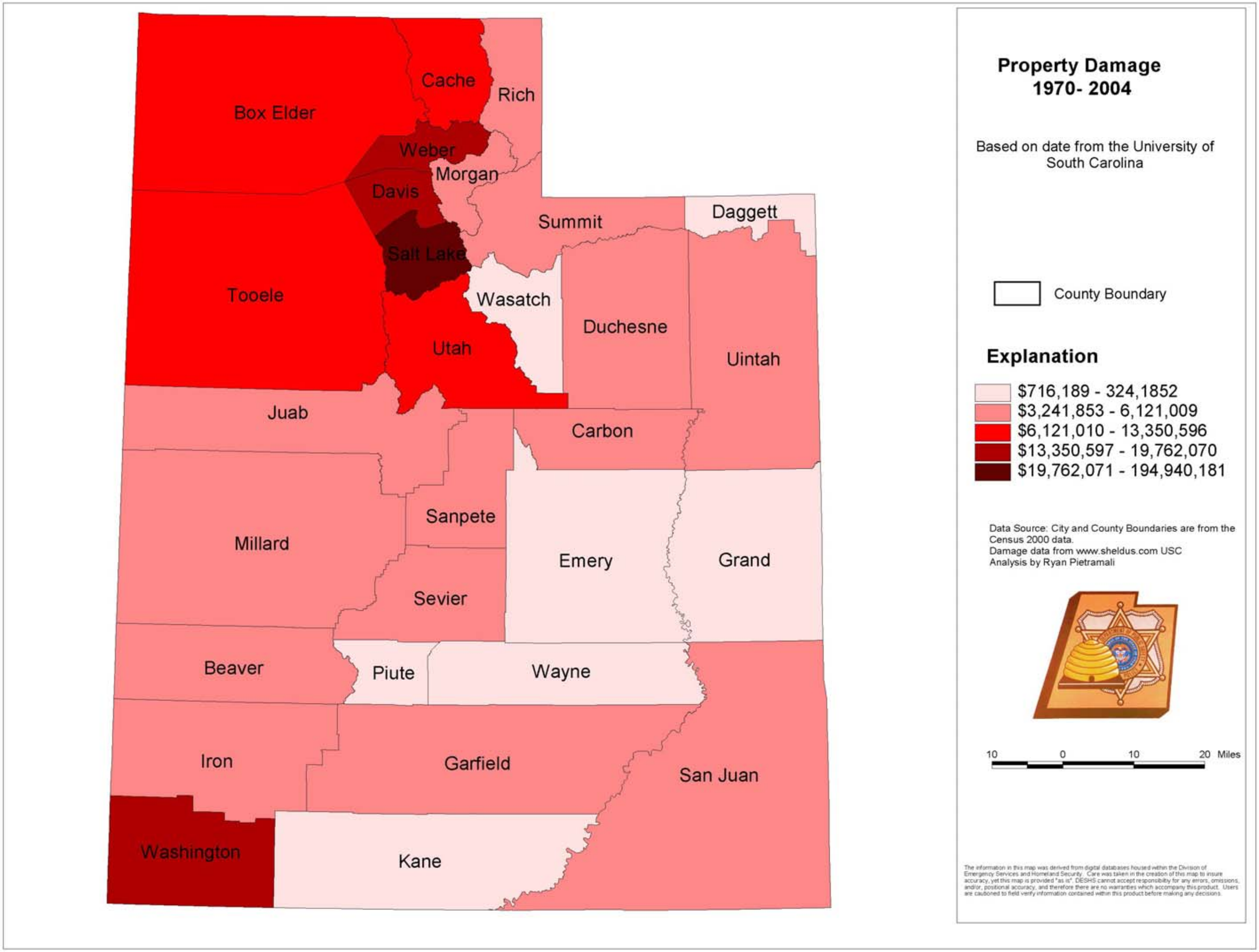
Estimating Potential Losses by State Facilities

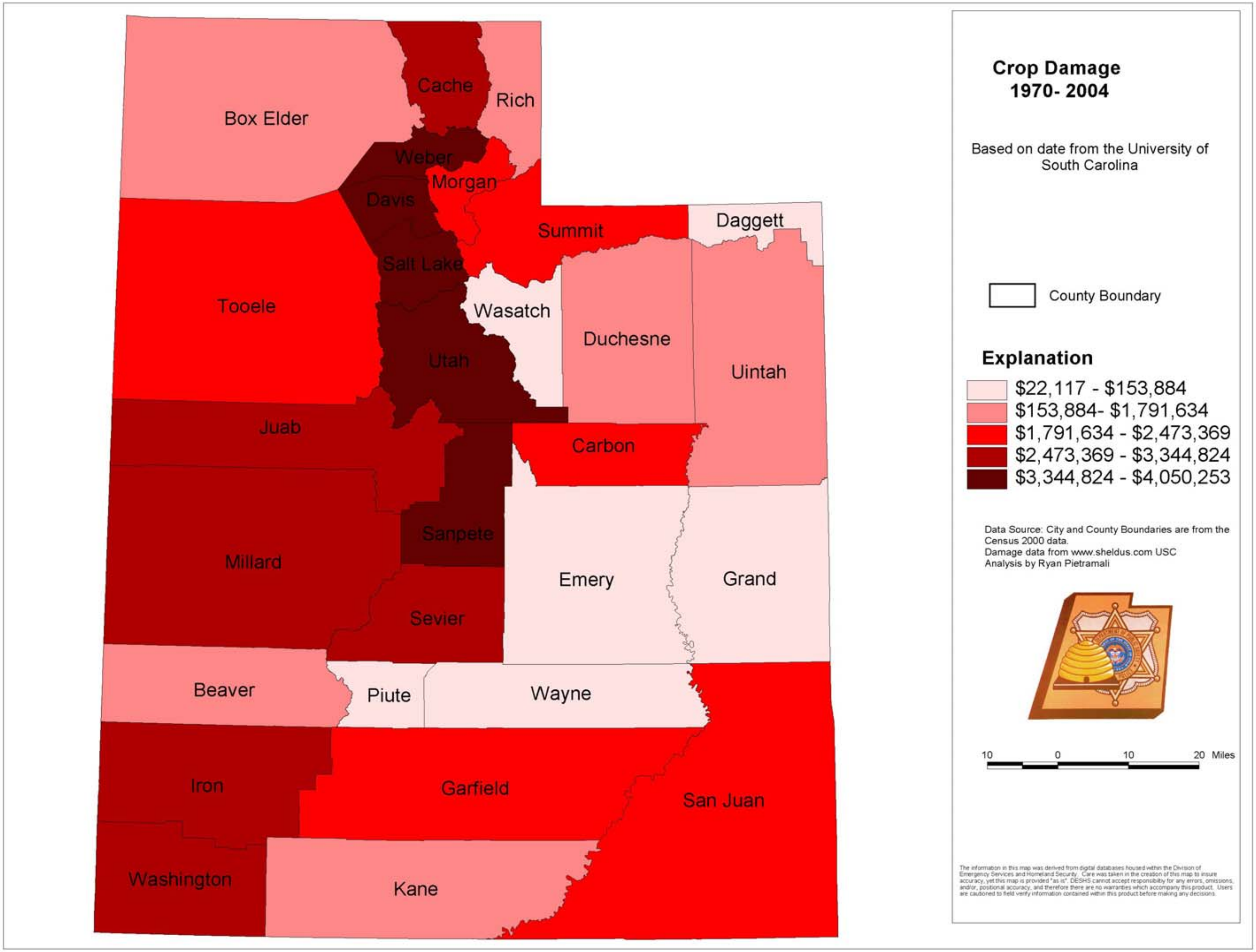
[The risk assessment shall include the following:]…[a]n overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in …the State risk assessment. The State shall estimate the potential dollar losses to State-owned or operated buildings, infrastructure, and critical facilities located

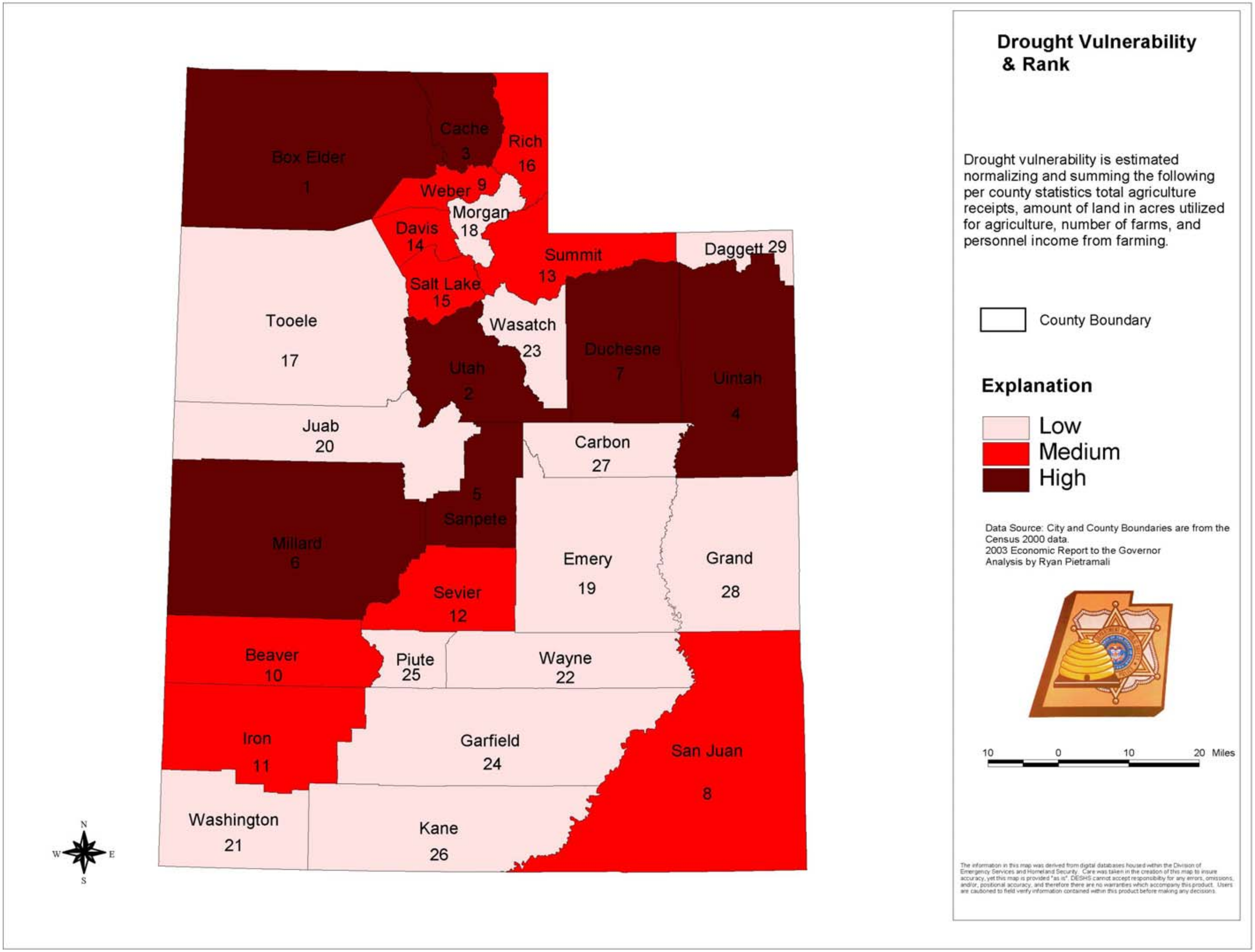
Estimating values for state owned facilities in landslide susceptibility areas was determined by multiplying the average insured value of state owned facilities in each county by the total number of vulnerable building in each county. Average insured value of state facilities per county was provided by State Risk Management a section of the State Department of Administrative Services.

Table I-26 Total Insured Value of State Owned Facilities in Wildfire Risk Areas

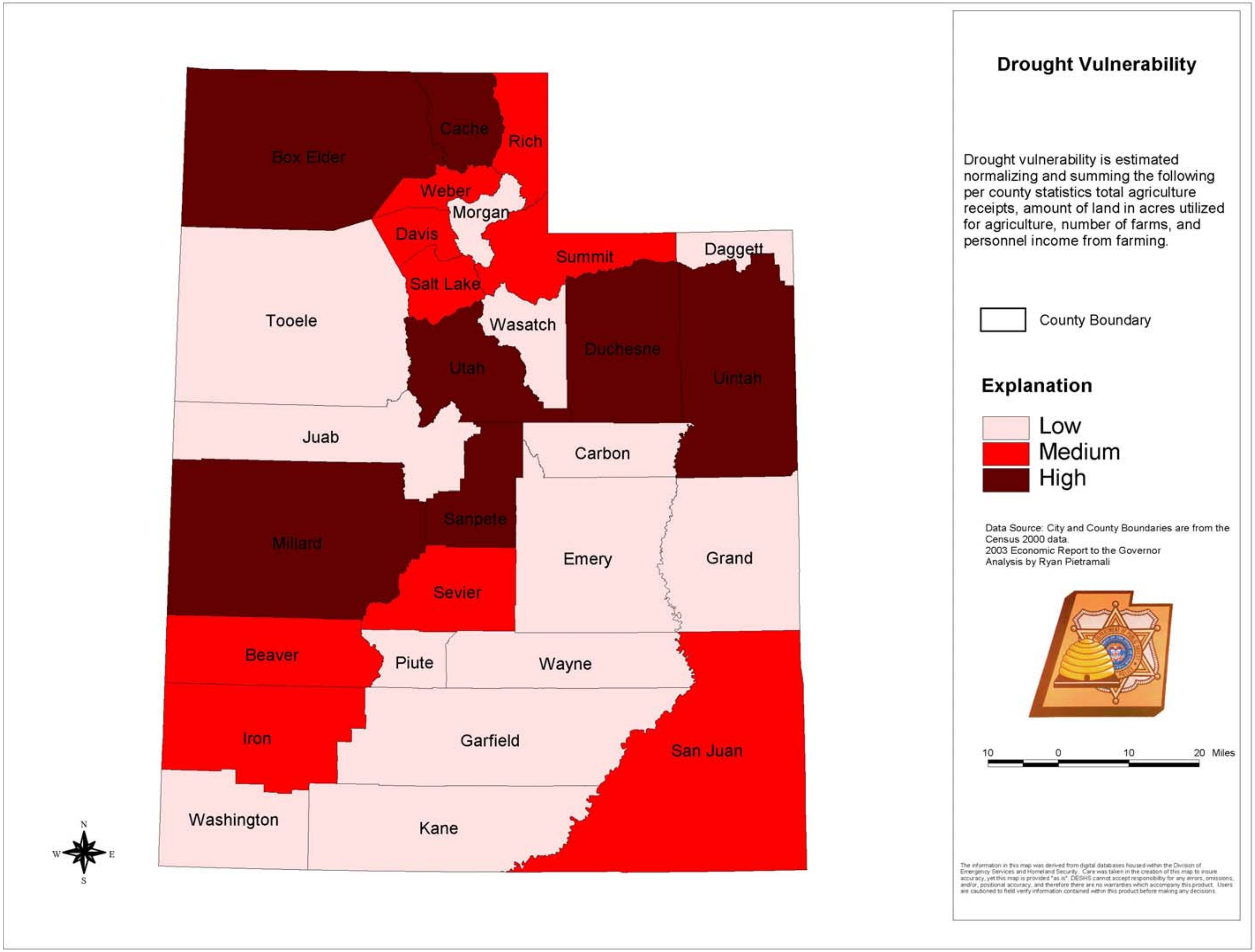
County	Total Vulnerable Structures	Estimated Insured Value
Beaver	4	$3,528,840.00
Box Elder	1	$1,735,313.35
Cache	0	0
Carbon	11	$11,750,241.14
Daggett	7	$2,197,265.21
Davis	3	$12,007,380.96
Duchesne	21	$23,097,673.83
Emery	8	$6,930,538.08
Garfield	5	$3,053,630.50
Grand	6	$3,471,618.84
Iron	8	$13,479,968.08
Juab	3	$2,312,425.56
Kane	3	$2,003,167.50
Millard	7	$7,747,962.32
Morgan	0	0
Piute	0	0
Rich	2	$647,686.46
Salt Lake	4	$13,498,403.76
San Juan	19	$16,321,052.25
Sanpete	2	$2,684,557.92
Sevier	2	$2,026,364.40
Summit	2	$2,953,018.36
Tooele	7	$12,923,498.70
Uintah	0	0
Utah	4	$12,930,652.36
Wasatch	3	$1,690,146.66
Washington	7	$17,661,858.90
Wayne	0	0
Weber	4	$13186795
Total	**143.00**	**$189,840,059.70**


Property Damage
1970- 2004
Based on date from the University of South Carolina
County Boundary
Explanation
$716,189 - 324,1852
$3,241,853 - 6,121,009
$6,121,010 - 13,350,596
$13,350,597 - 19,762,070
$19,762,071 - 194,940,181
Data Source: City and County Boundaries are from the Census 2000 data.
Damage data from www.sheldus.com USC
Analysis by Ryan Pietramali
10 0 10 20 Miles
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane

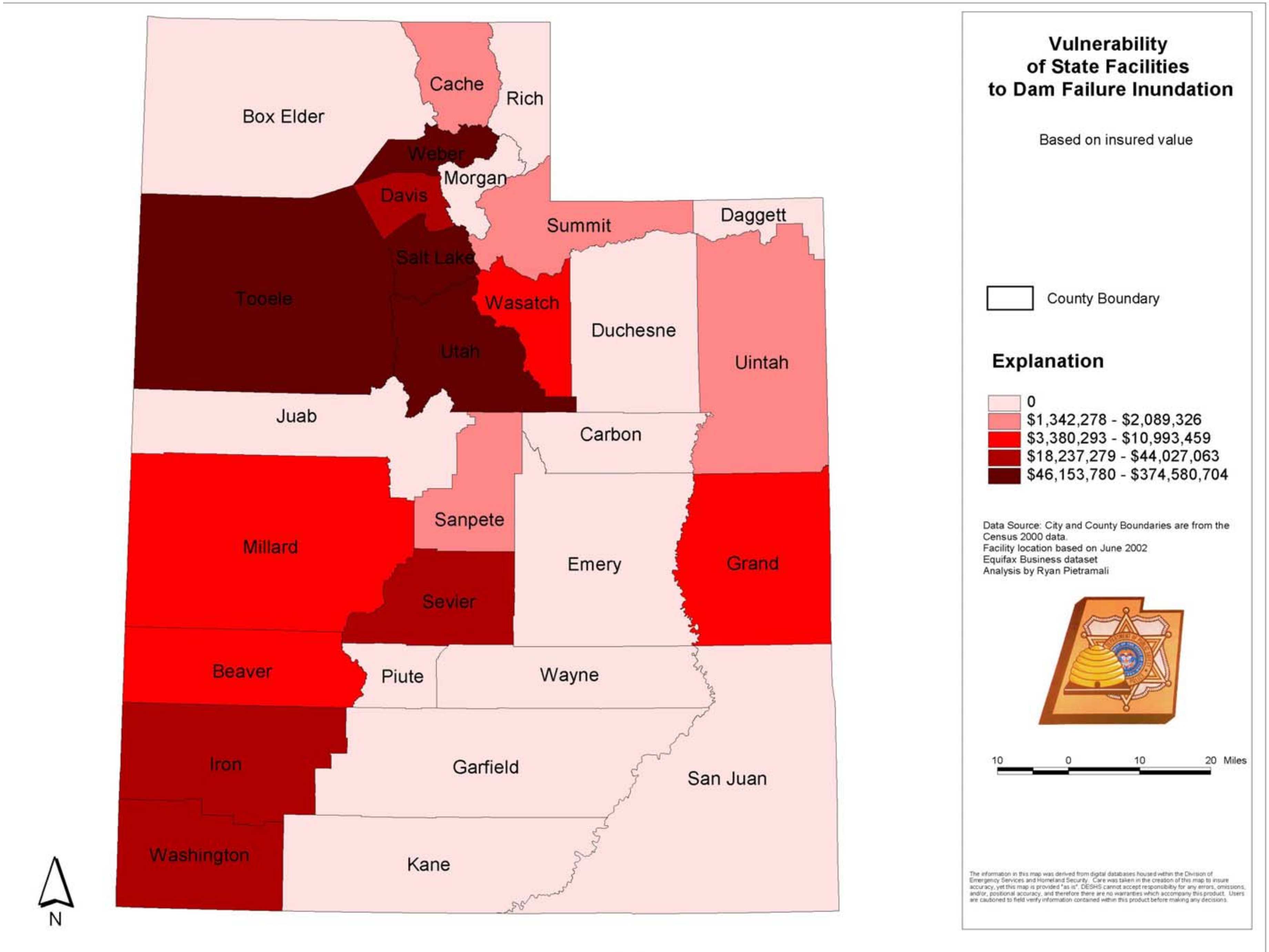

Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
Crop Damage
1970- 2004
Based on date from the University of South Carolina
County Boundary
Explanation
$22,117 - $153,884
$153,884- $1,791,634
$1,791,634 - $2,473,369
$2,473,369 - $3,344,824
$3,344,824 - $4,050,253
Data Source: City and County Boundaries are from the Census 2000 data.
Damage data from www.sheldus.com USC
Analysis by Ryan Pietramali
10 0 10 20 Miles

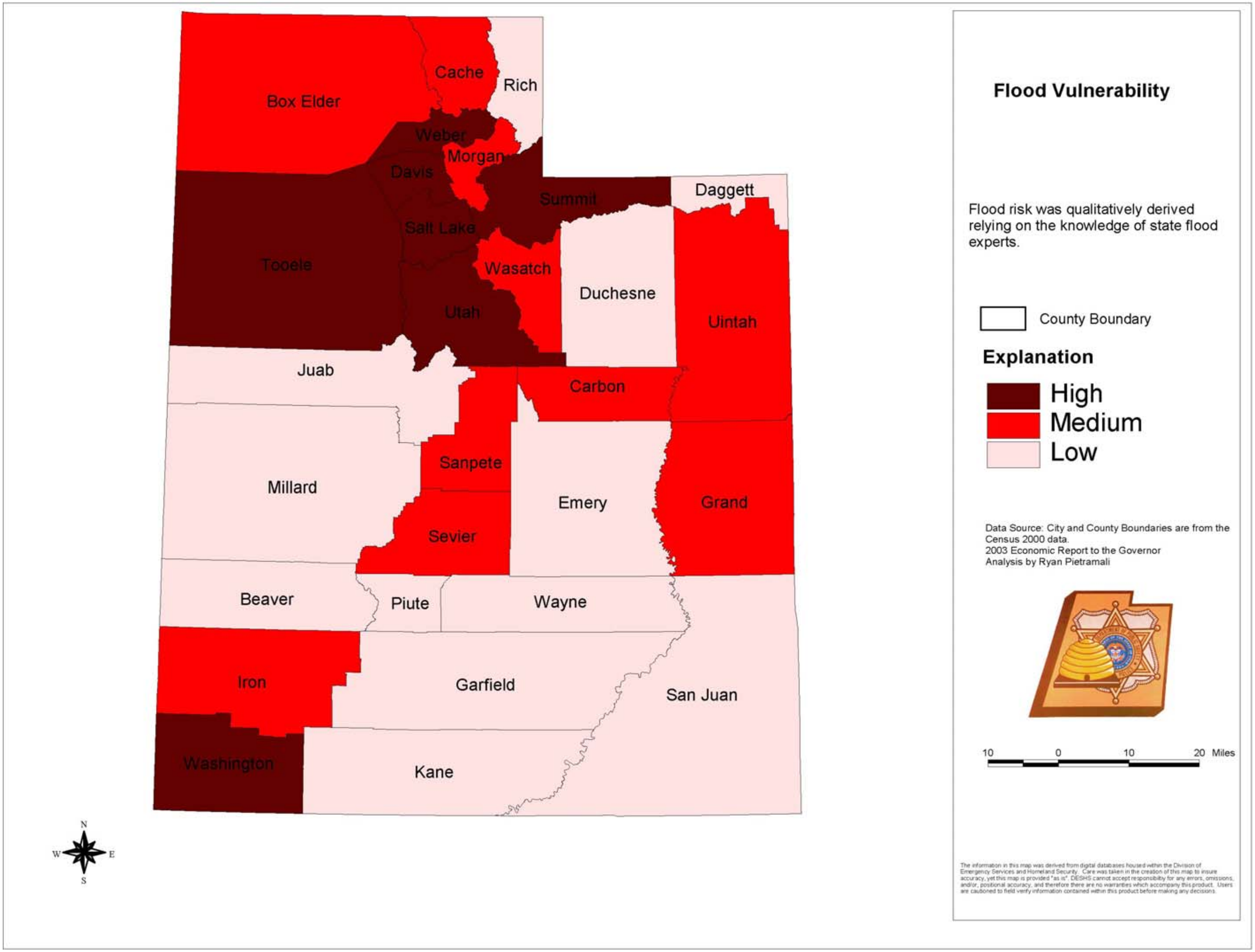


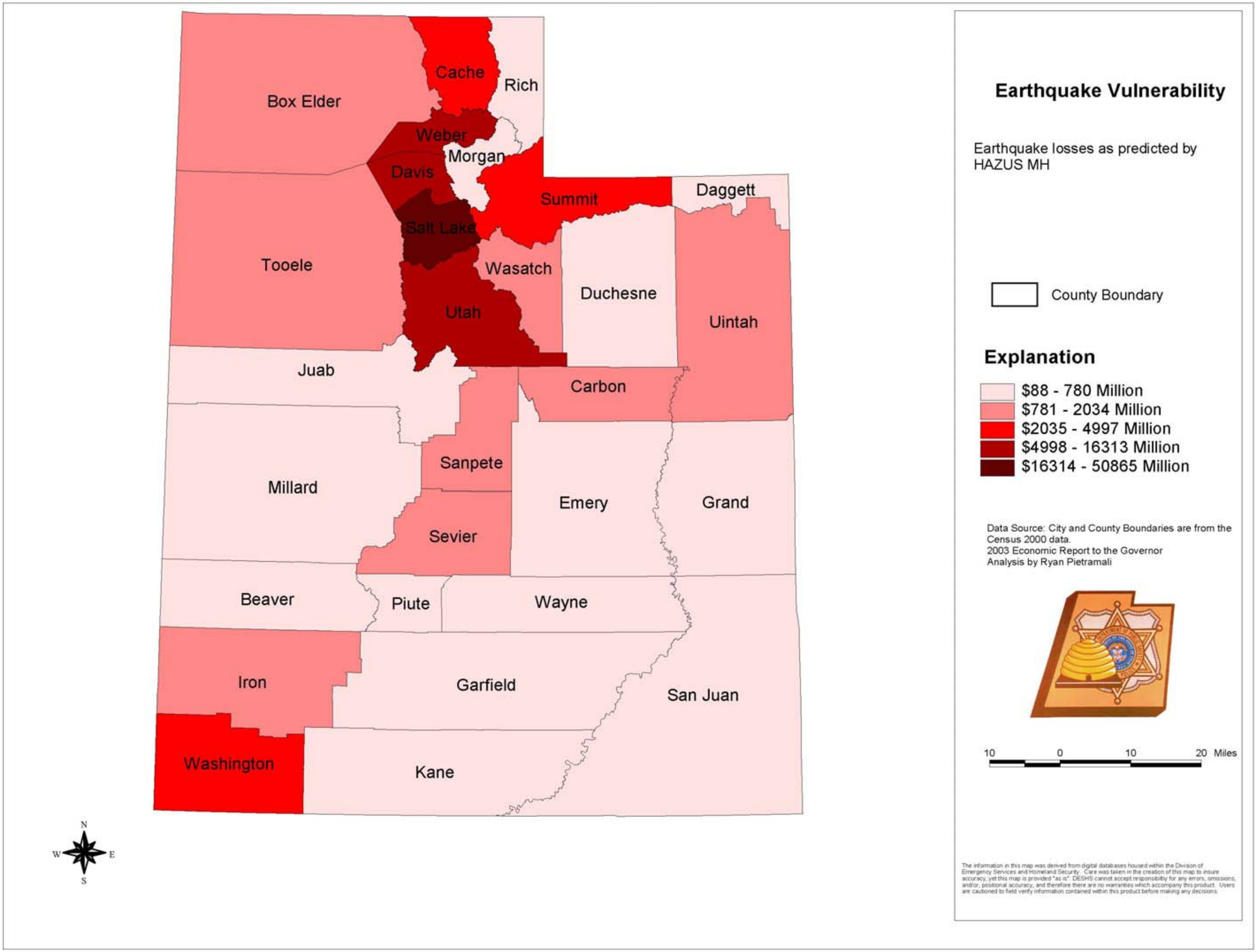
Drought Vulnerability & Rank
Box Elder 1
Cache 3
Rich 16
Weber 9
Morgan 18
Davis 14
Summit 13
Daggett 29
Salt Lake 15
Tooele 17
Wasatch 23
Duchesne 7
Uintah 4
Utah 2
Juab 20
Carbon 27
5 Sanpete
Millard 6
Emery 19
Grand 28
Sevier 12
Beaver 10
Piute 25
Wayne 22
Iron 11
Garfield 24
San Juan 8
Washington 21
Kane 26
N
W
E
S
Drought vulnerability is estimated normalizing and summing the following per county statistics total agriculture receipts, amount of land in acres utilized for agriculture, number of farms, and personnel income from farming.
County Boundary
Explanation
Low
Medium
High
Data Source: City and County Boundaries are from the Census 2000 data.
2003 Economic Report to the Governor
Analysis by Ryan Pietramali
10 0 10 20 Miles

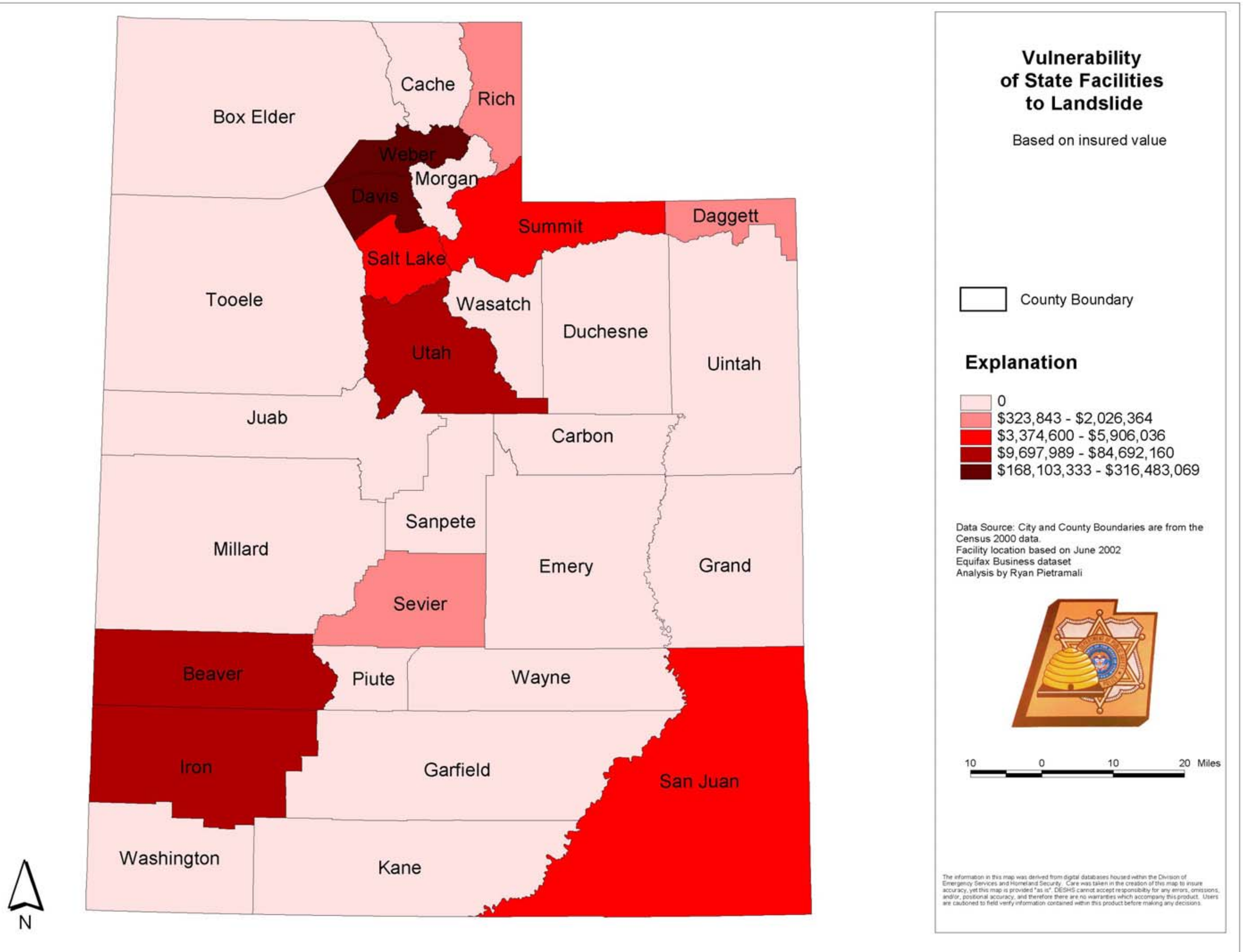


Drought Vulnerability
Drought vulnerability is estimated normalizing and summing the following per county statistics total agriculture receipts, amount of land in acres utilized for agriculture, number of farms, and personnel income from farming.
County Boundary
Explanation
Low
Medium
High
Data Source: City and County Boundaries are from the Census 2000 data.
2003 Economic Report to the Governor
Analysis by Ryan Pietramali
10 0 10 20 Miles
N
W
E
S
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Millard
Sanpete
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane

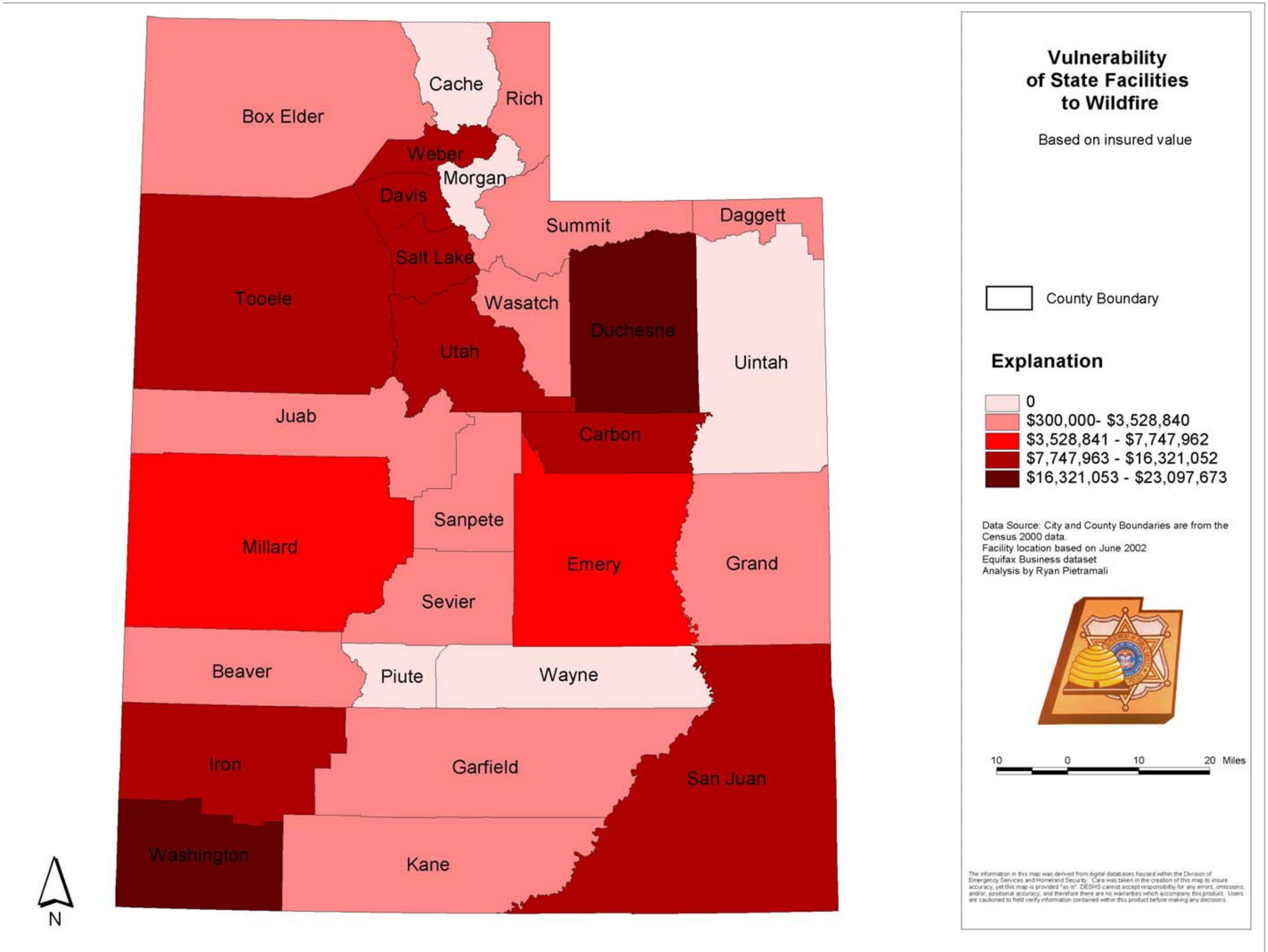

Vulnerability of State Facilities to Dam Failure Inundation
Based on insured value
County Boundary
Explanation
0
$1,342,278 - $2,089,326
$3,380,293 - $10,993,459
$18,237,279 - $44,027,063
$46,153,780 - $374,580,704
Data Source: City and County Boundaries are from the Census 2000 data.
Facility location based on June 2002
Equifax Business dataset
Analysis by Ryan Pietramali
10
0
10
20 Miles
N
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane

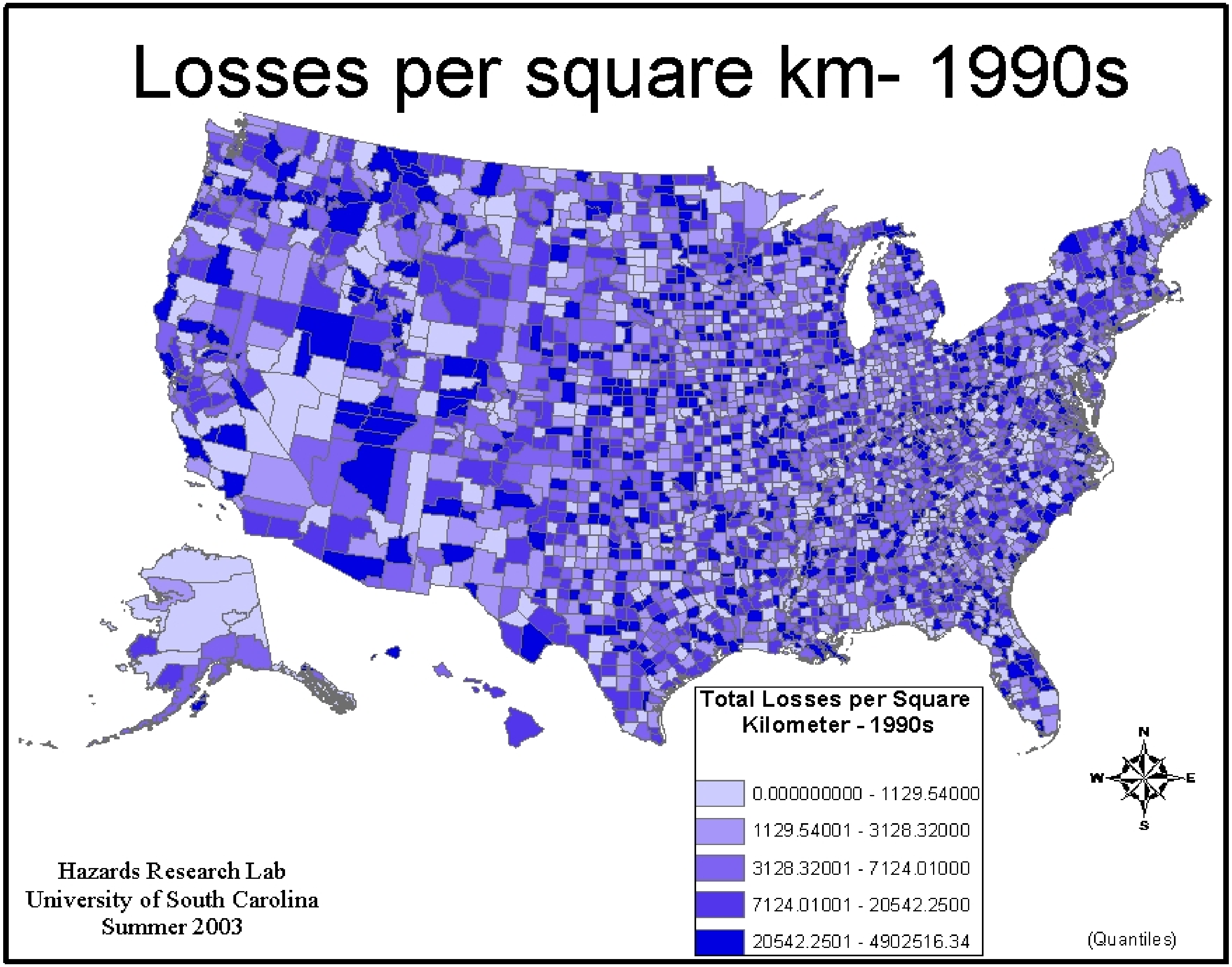

Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
N
W
E
S
Flood Vulnerability
Flood risk was qualitatively derived relying on the knowledge of state flood experts.
County Boundary
Explanation
High
Medium
Low
Data Source: City and County Boundaries are from the Census 2000 data.
2003 Economic Report to the Governor
Analysis by Ryan Pietramali
10 0 10 20 Miles
The information in this map was derived from digital databases housed within the Division of Emergency Services and Homeland Security. Care was taken in the creation of this map to insure accuracy, yet this map is provided "as is". DESHS cannot accept responsibilty for any errors, omissions, and/or, positional accuracy, and therefore there are no warranties which accompany this product. Users are cautioned to field verify information contained within this product before making any decisions.


Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Uintah
Utah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
N
W
E
S
Earthquake Vulnerability
Earthquake losses as predicted by HAZUS MH
County Boundary
Explanation
$88 - 780 Million
$781 - 2034 Million
$2035 - 4997 Million
$4998 - 16313 Million
$16314 - 50865 Million
Data Source: City and County Boundaries are from the Census 2000 data.
2003 Economic Report to the Governor
Analysis by Ryan Pietramali
10
0
10
20 Miles
The information in this map was derived from digital databases housed within the Division of Emergency Services and Homeland Security. Care was taken in the creation of this map to insure accuracy, yet this map is provided "as is". DESHS cannot accept responsibility for any errors, omissions, and/or, positional accuracy, and therefore there are no warranties which accompany this product. Users are cautioned to field verify information contained within this product before making any decisions.

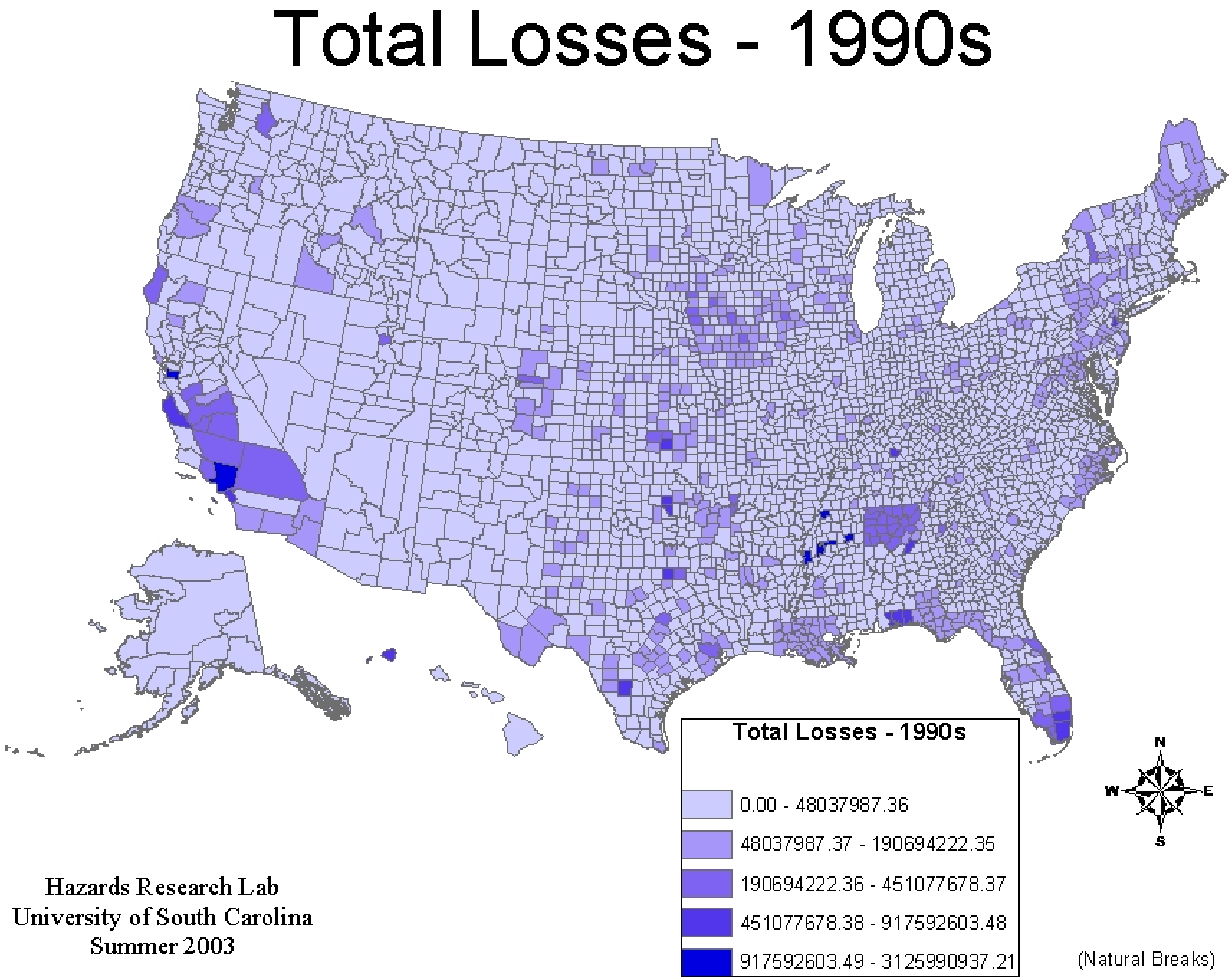


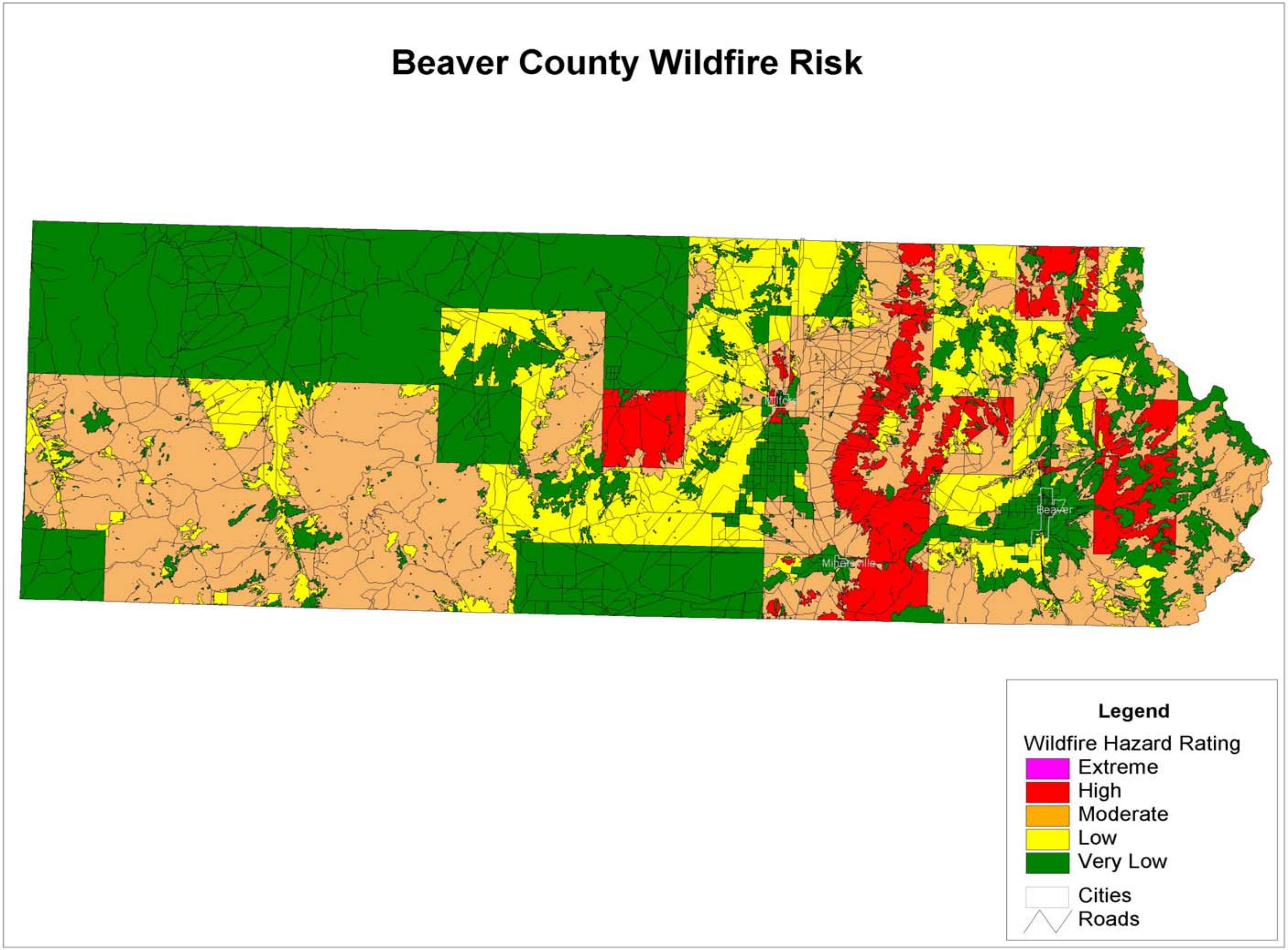
Vulnerability of State Facilities to Landslide
Based on insured value
County Boundary
Explanation
0
$323,843 - $2,026,364
$3,374,600 - $5,906,036
$9,697,989 - $84,692,160
$168,103,333 - $316,483,069
Data Source: City and County Boundaries are from the Census 2000 data.
Facility location based on June 2002
Equifax Business dataset
Analysis by Ryan Pietramali
10 0 10 20 Miles
N
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Uintah
Utah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane

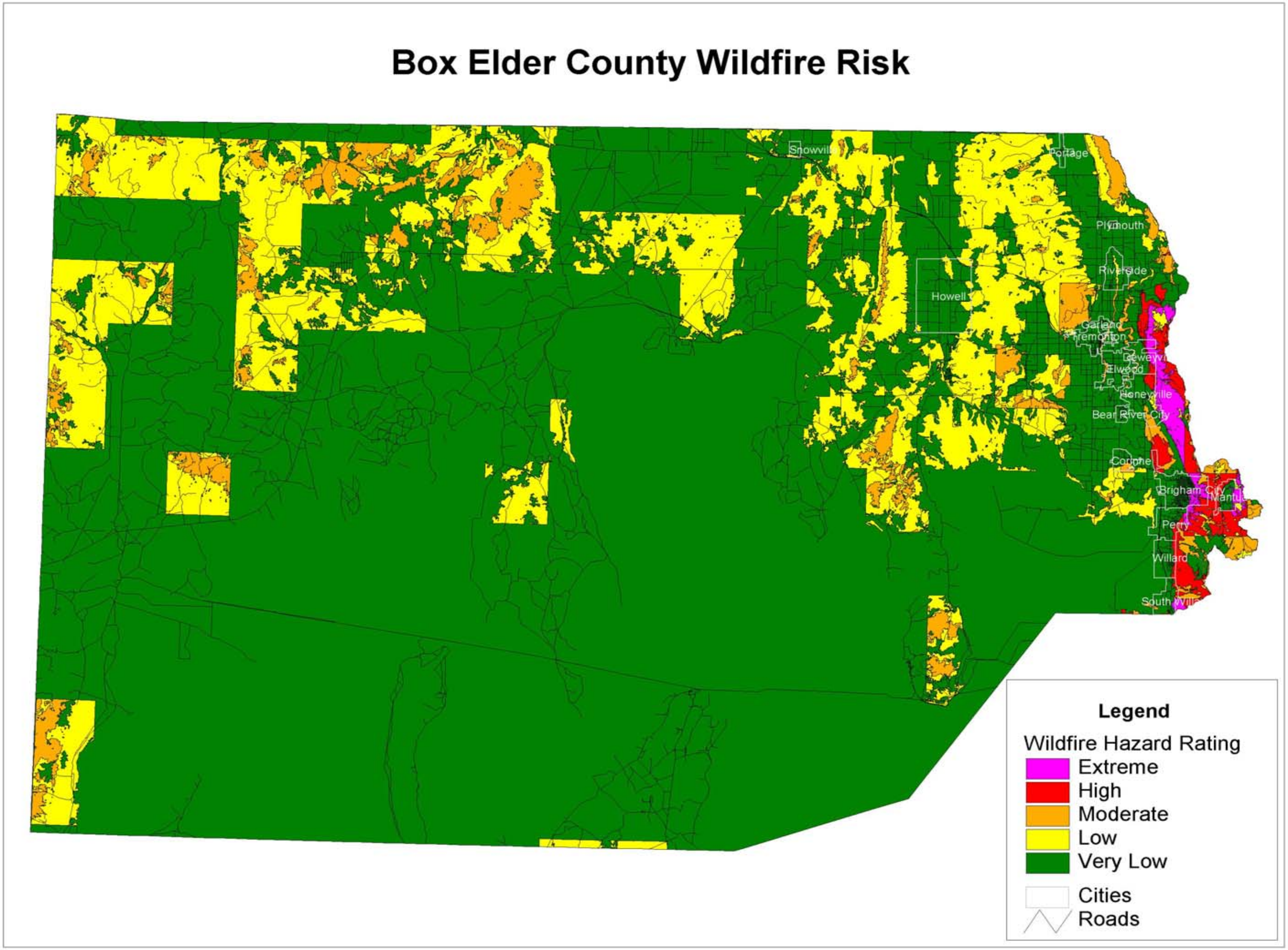

Vulnerability
of State Facilities
to Wildfire
Based on insured value
County Boundary
Explanation
0
$300,000- $3,528,840
$3,528,841 - $7,747,962
$7,747,963 - $16,321,052
$16,321,053 - $23,097,673
Data Source: City and County Boundaries are from the Census 2000 data.
Facility location based on June 2002
Equifax Business dataset
Analysis by Ryan Pietramali
10 0 10 20 Miles
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Wasatch
Duchesne
Utah
Uintah
Juab
Carbon
Sanpete
Millard
Emery
Grand
Sevier
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
N



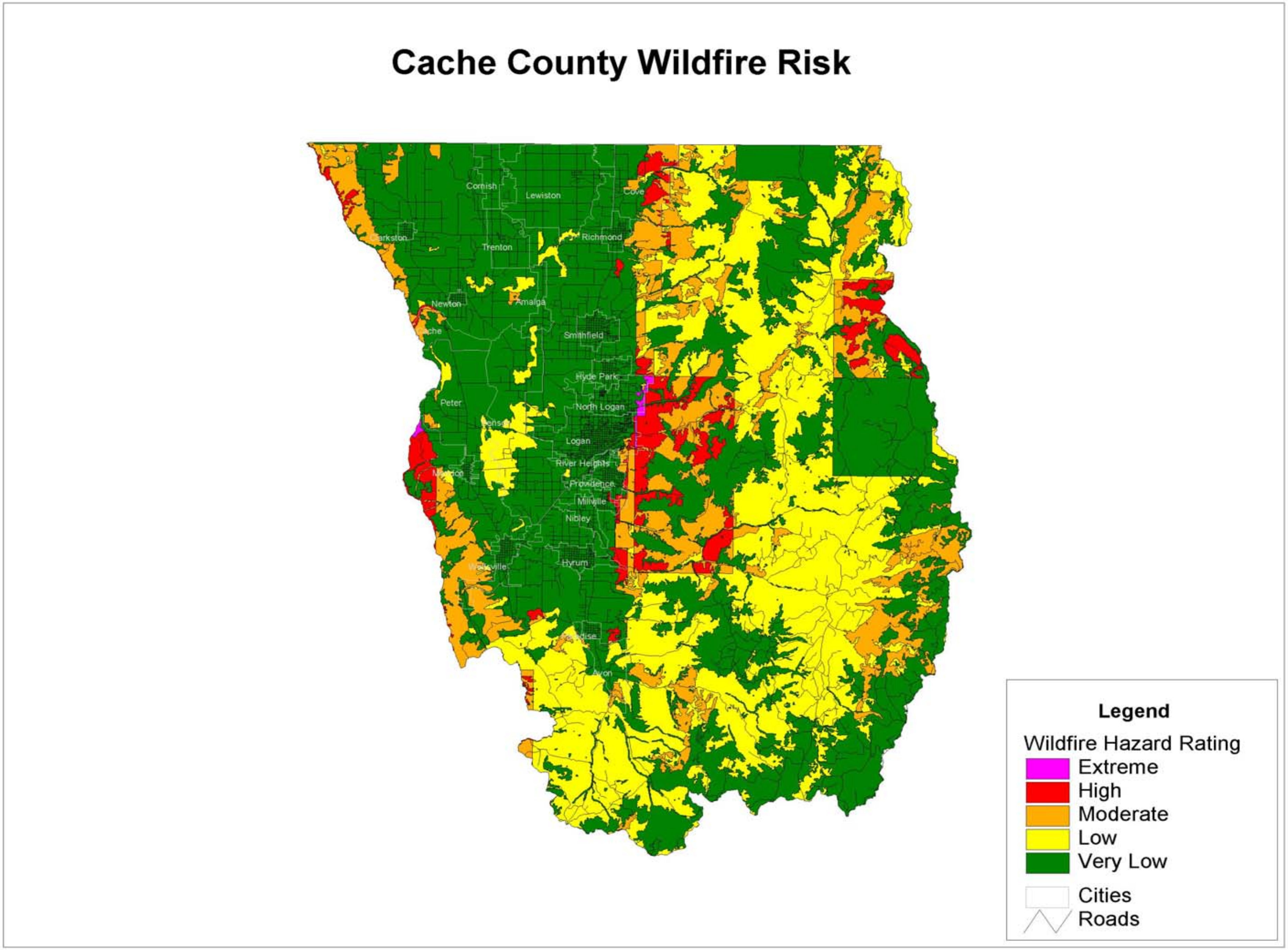
Losses per square km- 1990s
Total Losses per Square Kilometer - 1990s
0.000000000 - 1129.54000
1129.54001 - 3128.32000
3128.32001 - 7124.01000
7124.01001 - 20542.2500
20542.2501 - 4902516.34
(Quantiles)
N
W
E
S
Hazards Research Lab
University of South Carolina
Summer 2003

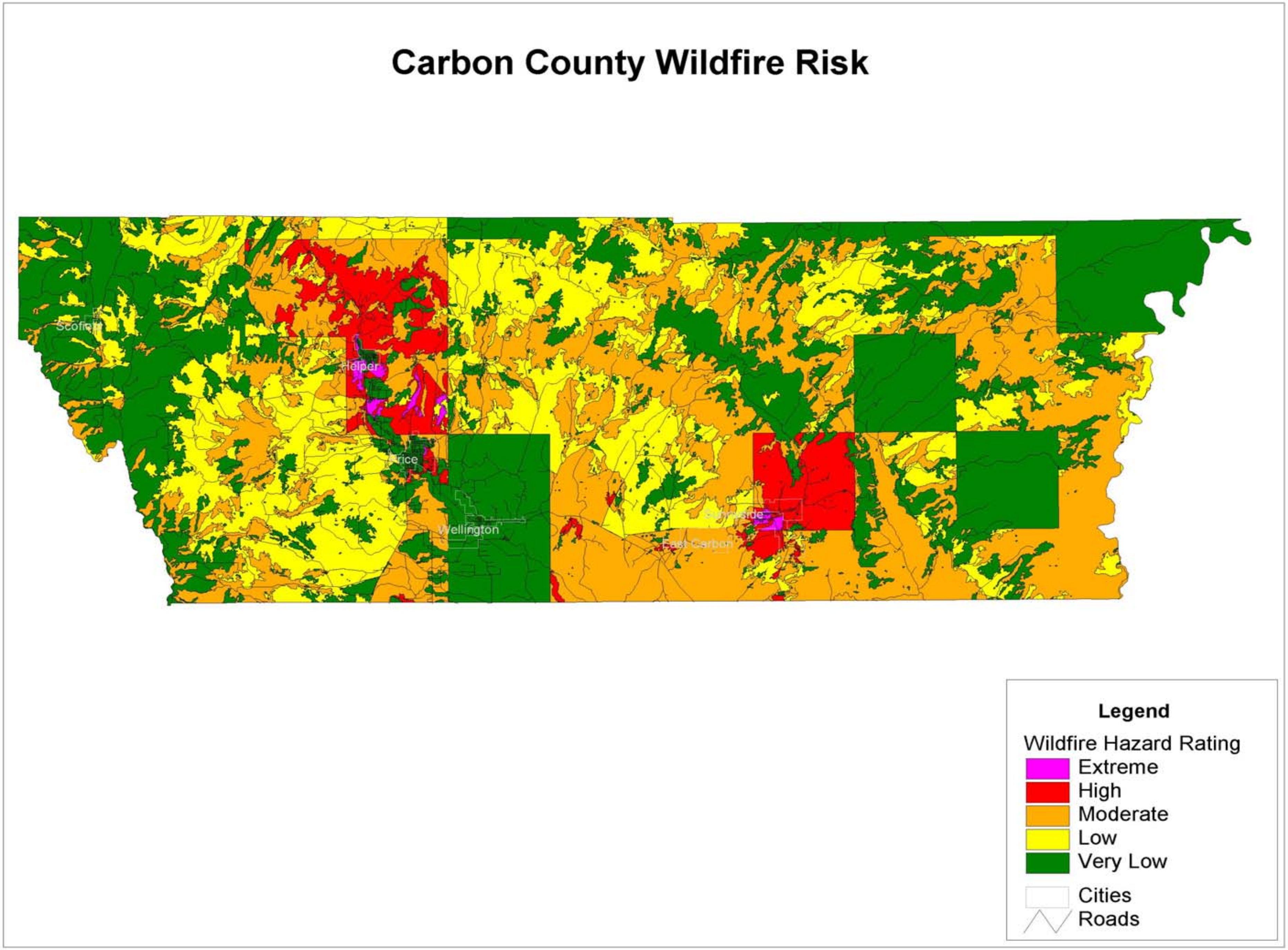

Total Losses - 1990s
Total Losses - 1990s
0.00 - 48037987.36
48037987.37 - 190694222.35
190694222.36 - 451077678.37
451077678.38 - 917592603.48
917592603.49 - 3125990937.21
N
W
E
S
(Natural Breaks)
Hazards Research Lab
University of South Carolina
Summer 2003


Beaver County Wildfire Risk
Milford
Beaver
Minersville
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

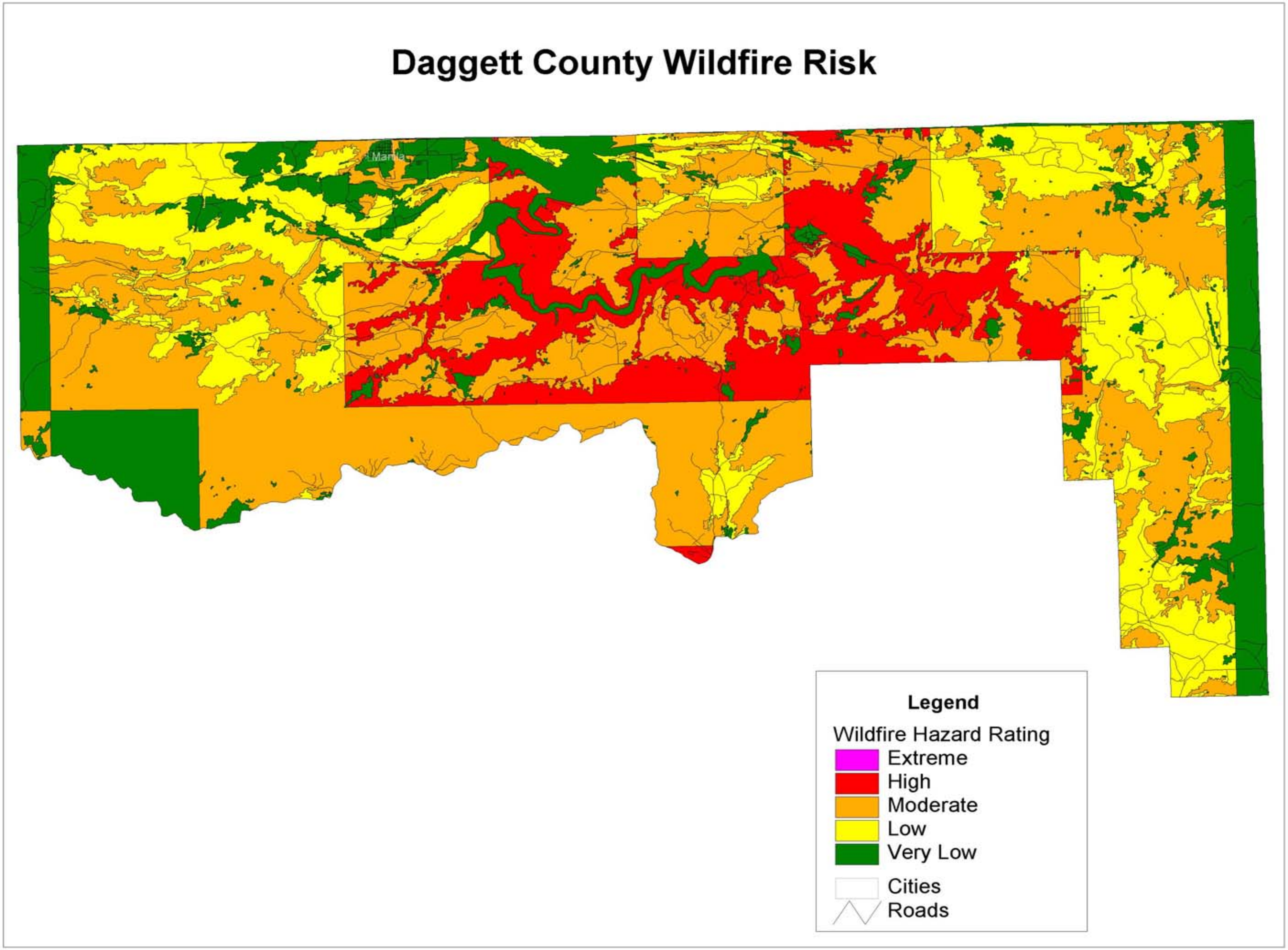


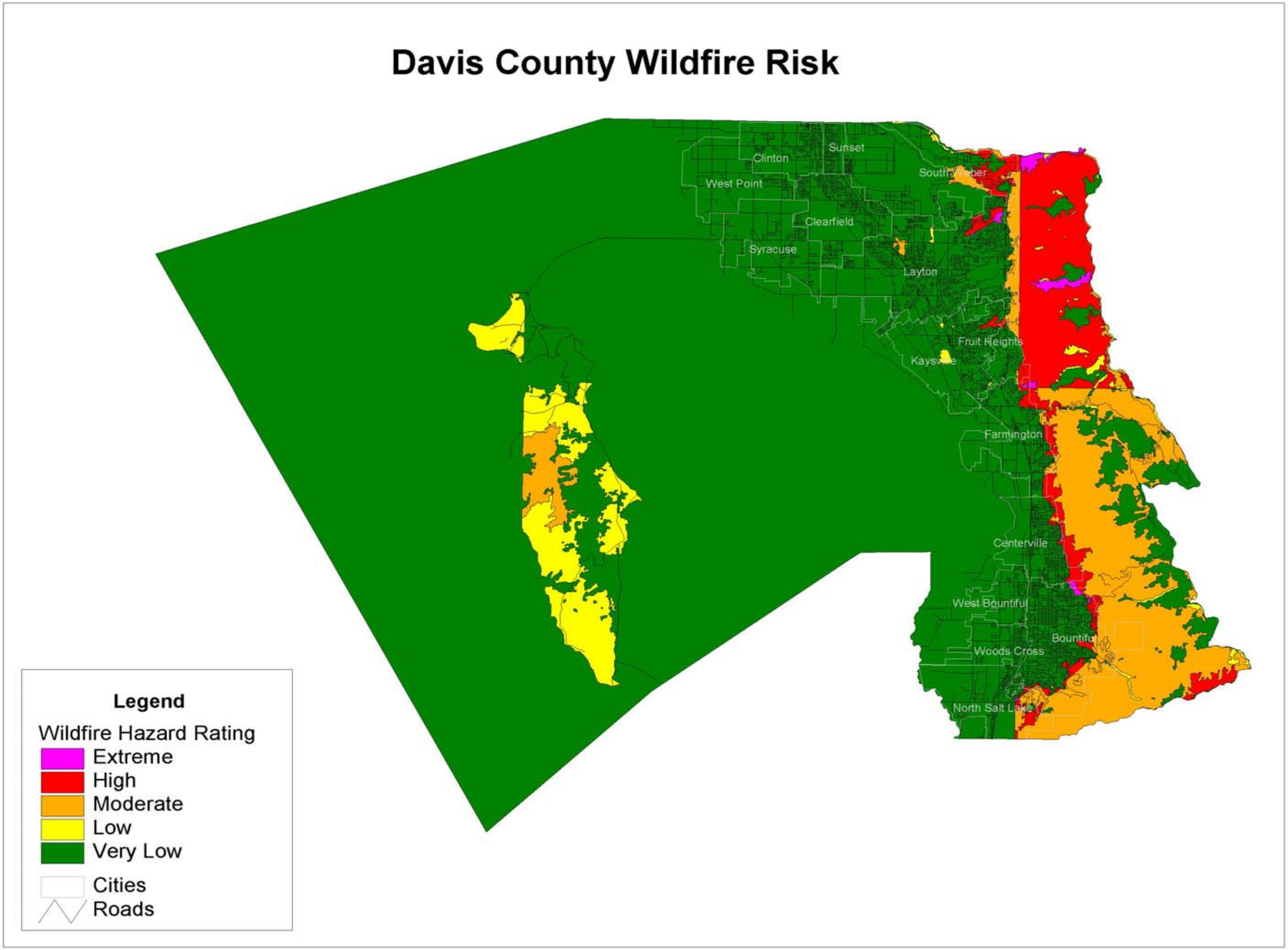
Box Elder County Wildfire Risk
Snowville
Portage
Plymouth
Riverside
Howell
Garland
Tremonton
Elwood
Honeyville
Bear River City
Corinne
Brigham City
Mantua
Perry
Willard
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads


Cache County Wildfire Risk
Cornish
Lewiston
Cove
Clarkston
Trenton
Richmond
Newton
Amalga
Smithfield
Hyde Park
Peter
North Logan
Logan
River Heights
Providence
Millville
Nibley
Hyrum
Wellsville
Avon
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads



Carbon County Wildfire Risk
Helper
Wellington
East Carbon
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

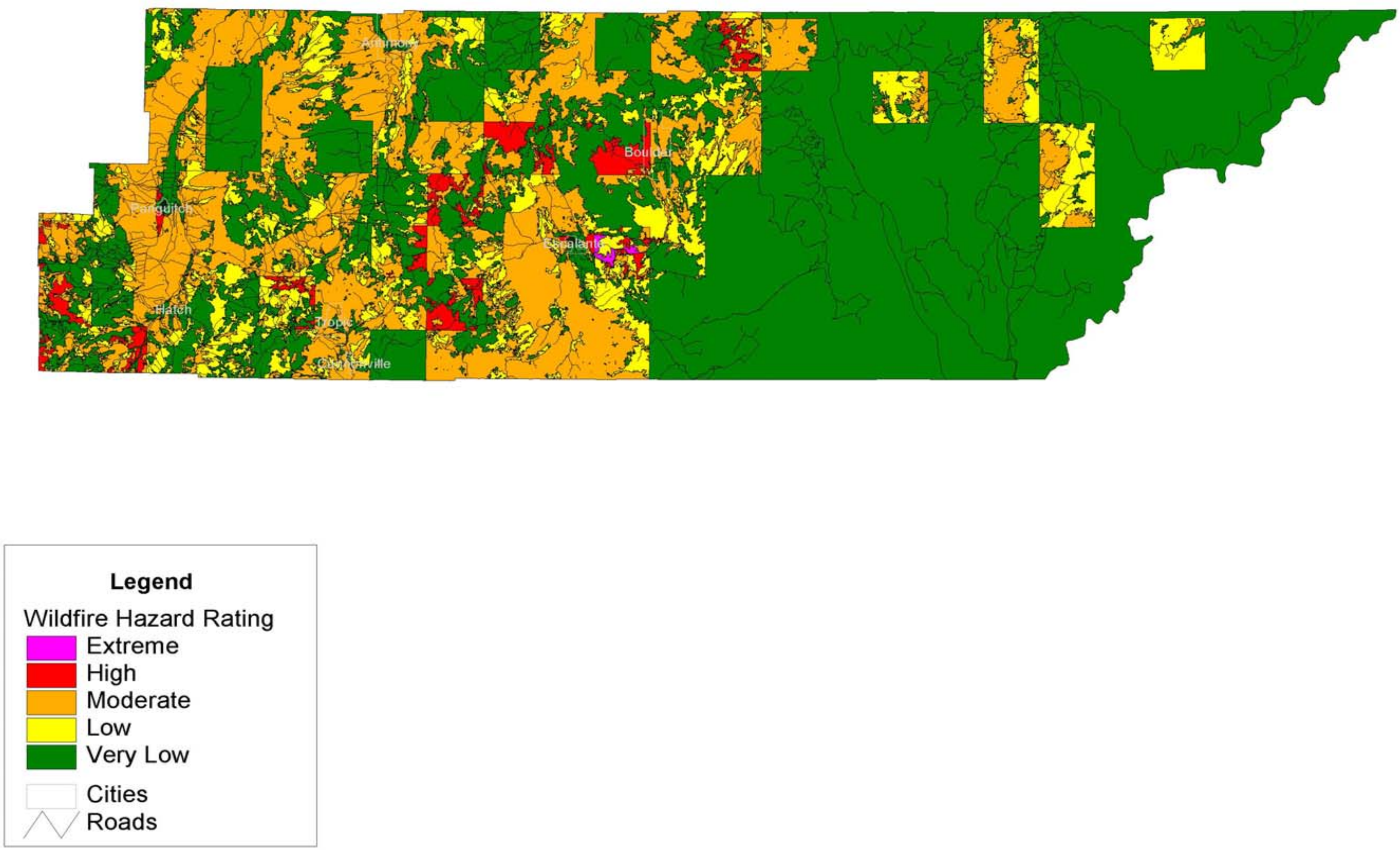

Daggett County Wildfire Risk
Manila
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

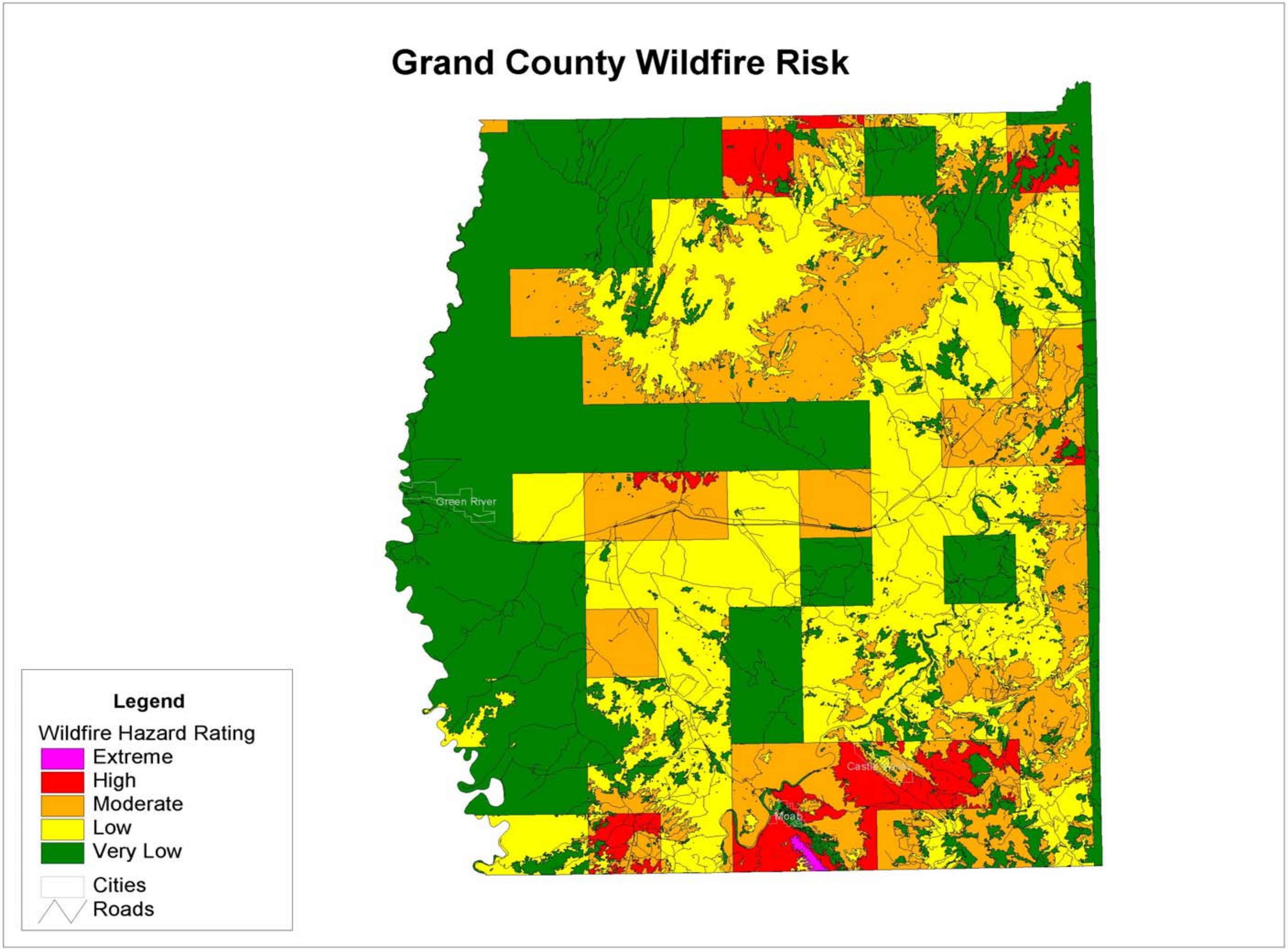

Davis County Wildfire Risk
Sunset
Clinton
West Point
South Weber
Clearfield
Syracuse
Layton
Fruit Heights
Kaysville
Farmington
Centerville
West Bountiful
Bountiful
Woods Cross
North Salt Lake
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

Duchesne County Wildfire Risk

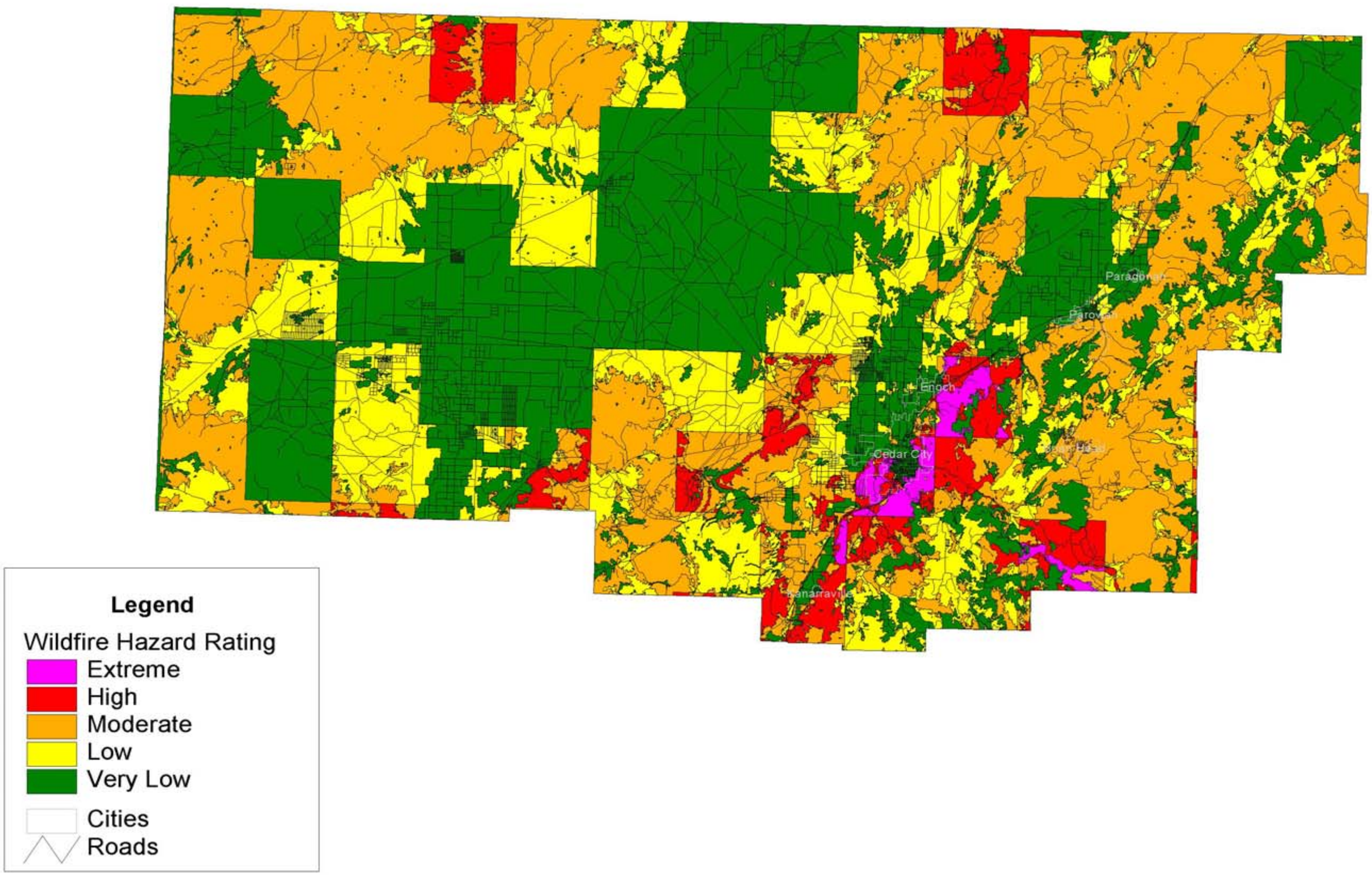
Emery County Wildfire Risk

Garfield County Wildfire Risk

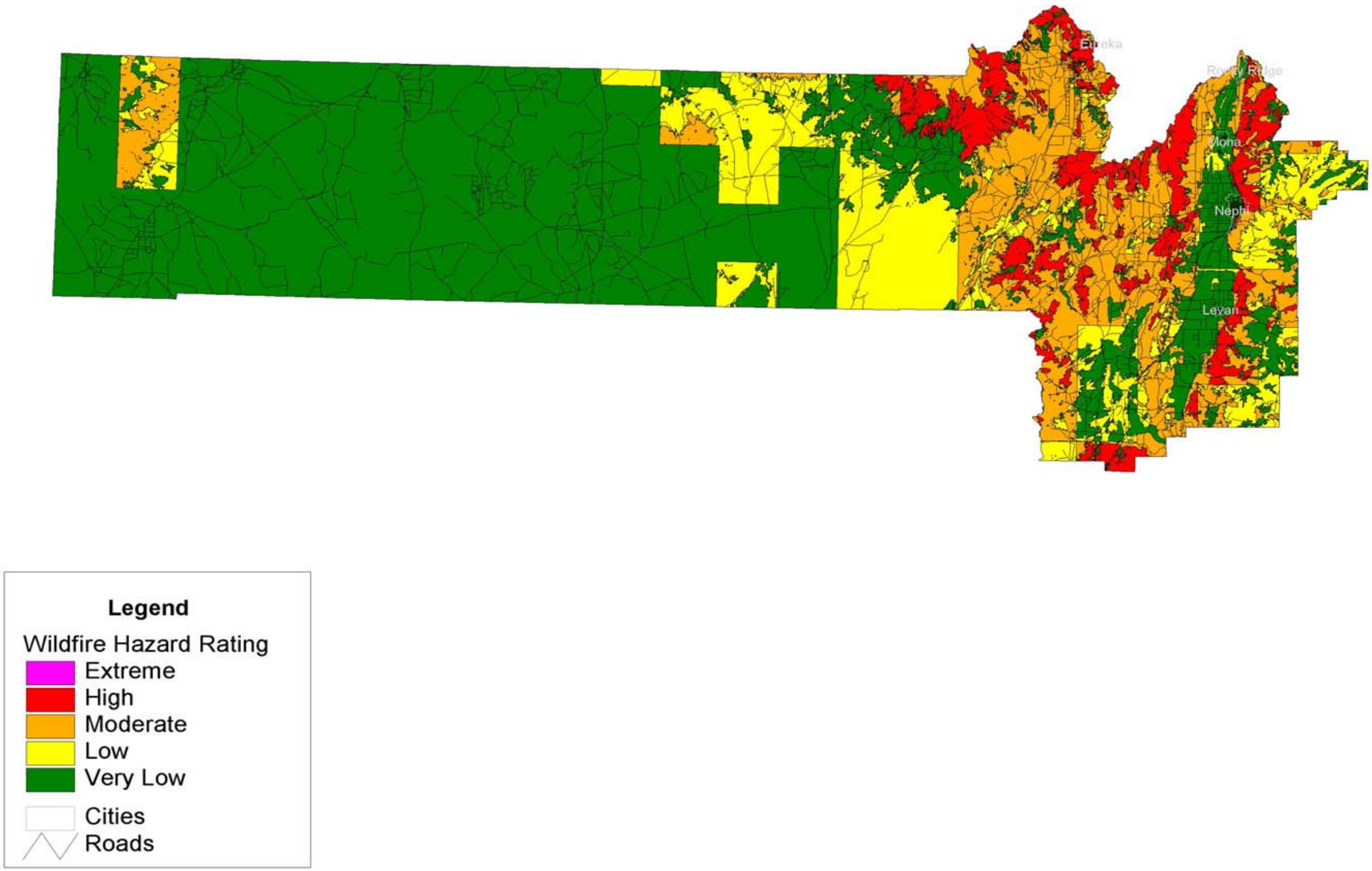


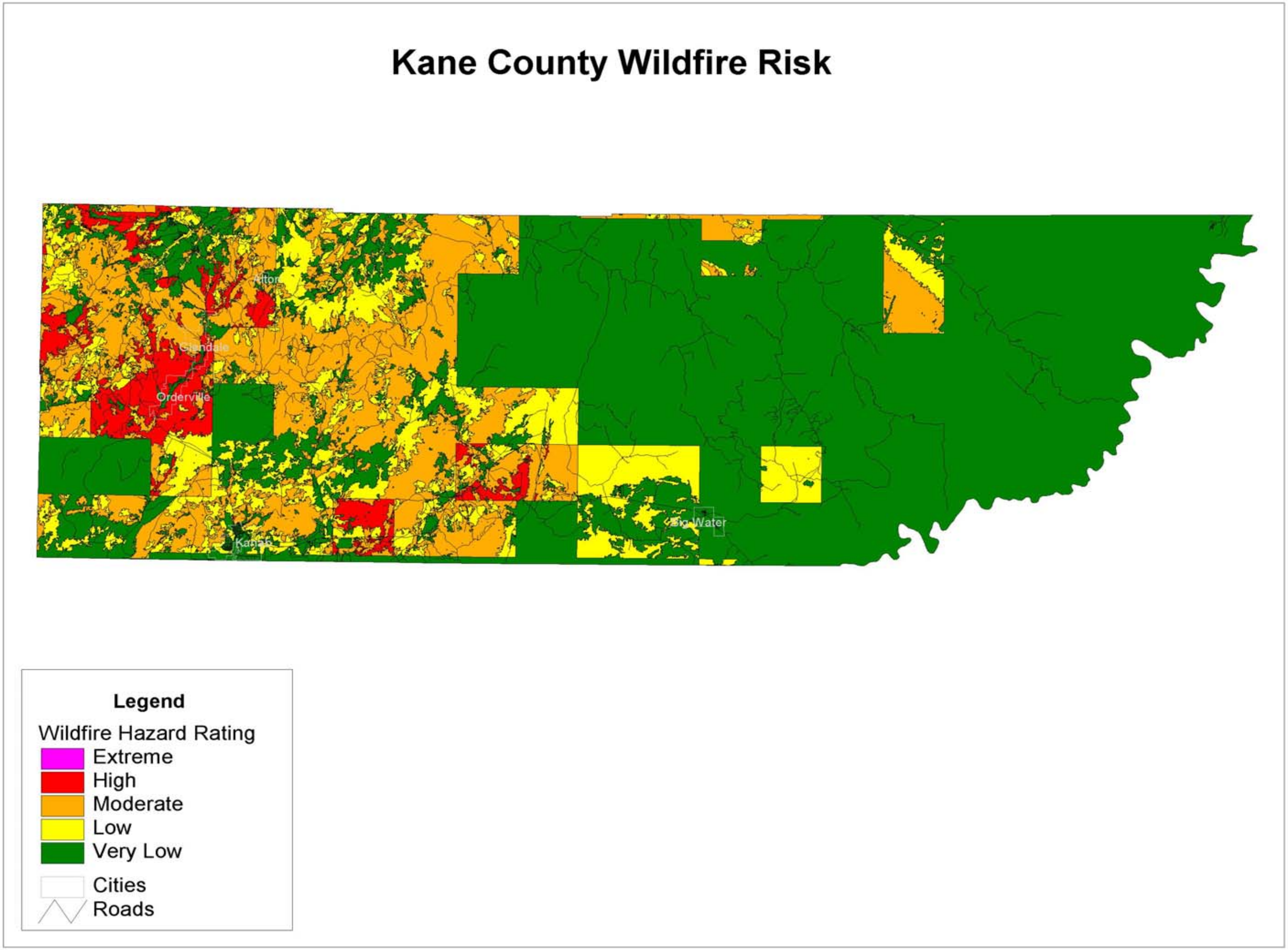

Grand County Wildfire Risk
Green River
Moab
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

Iron County Wildfire Risk

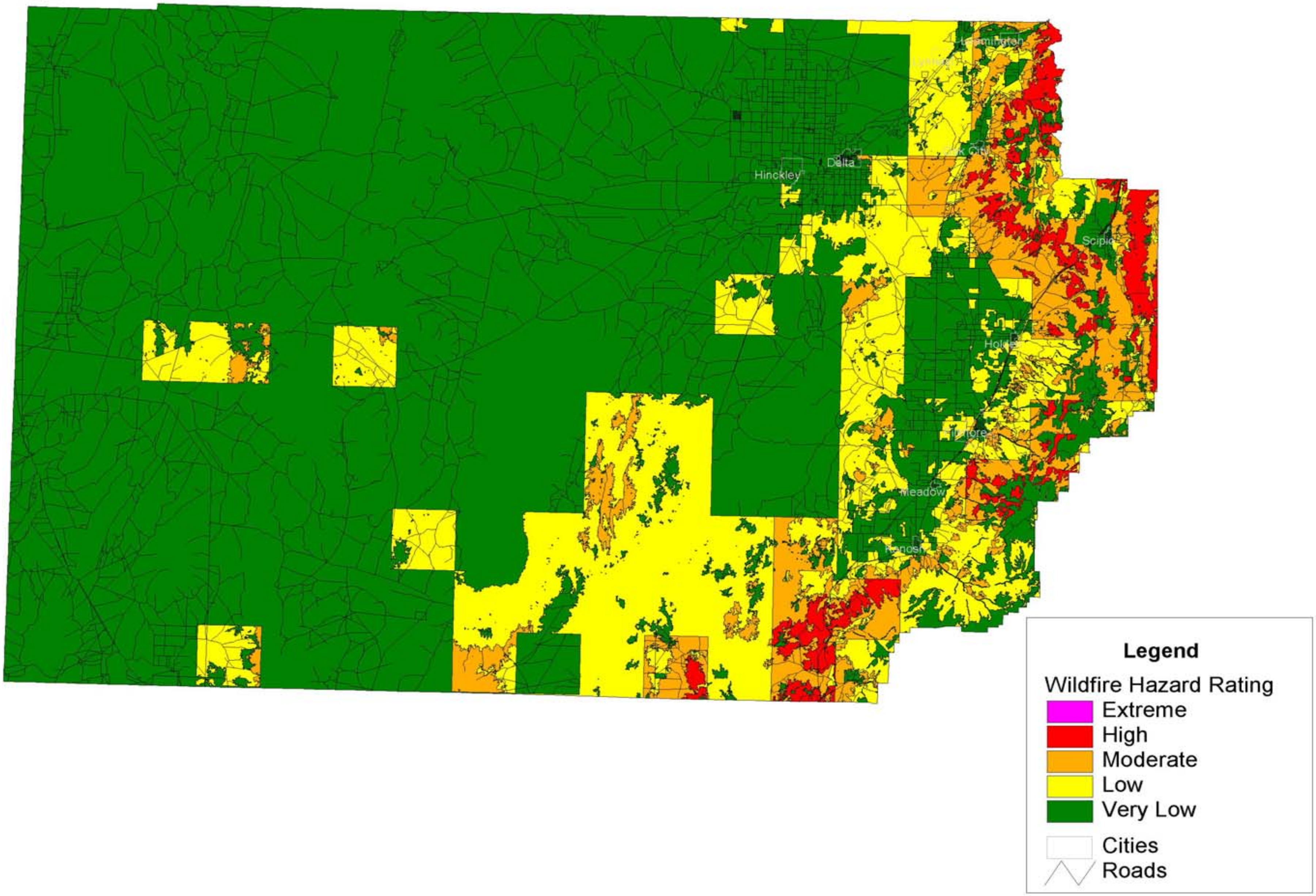


Juab County Wildfire Risk

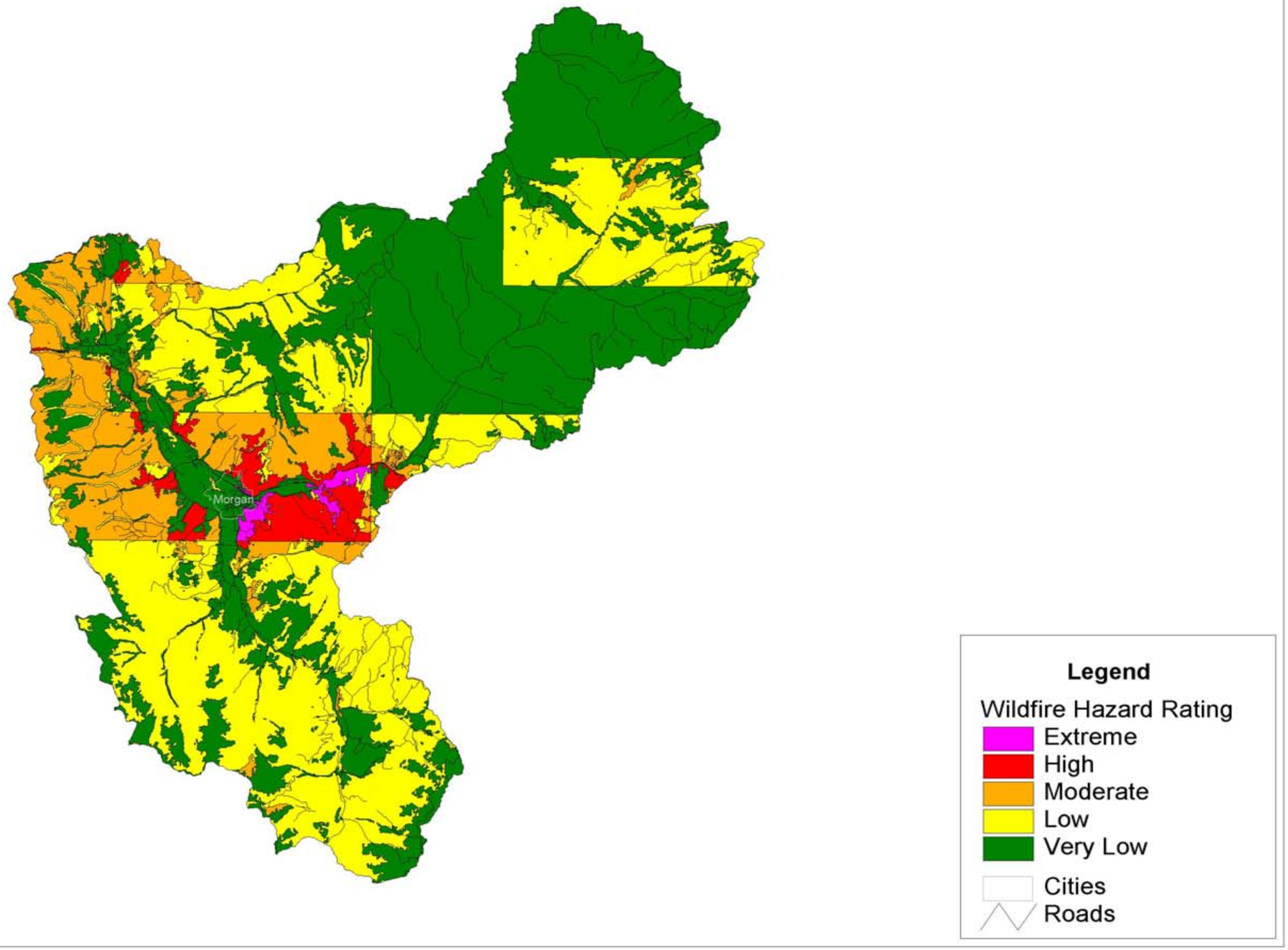



Kane County Wildfire Risk
Alton
Glendale
Orderville
Kanab
Big Water
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

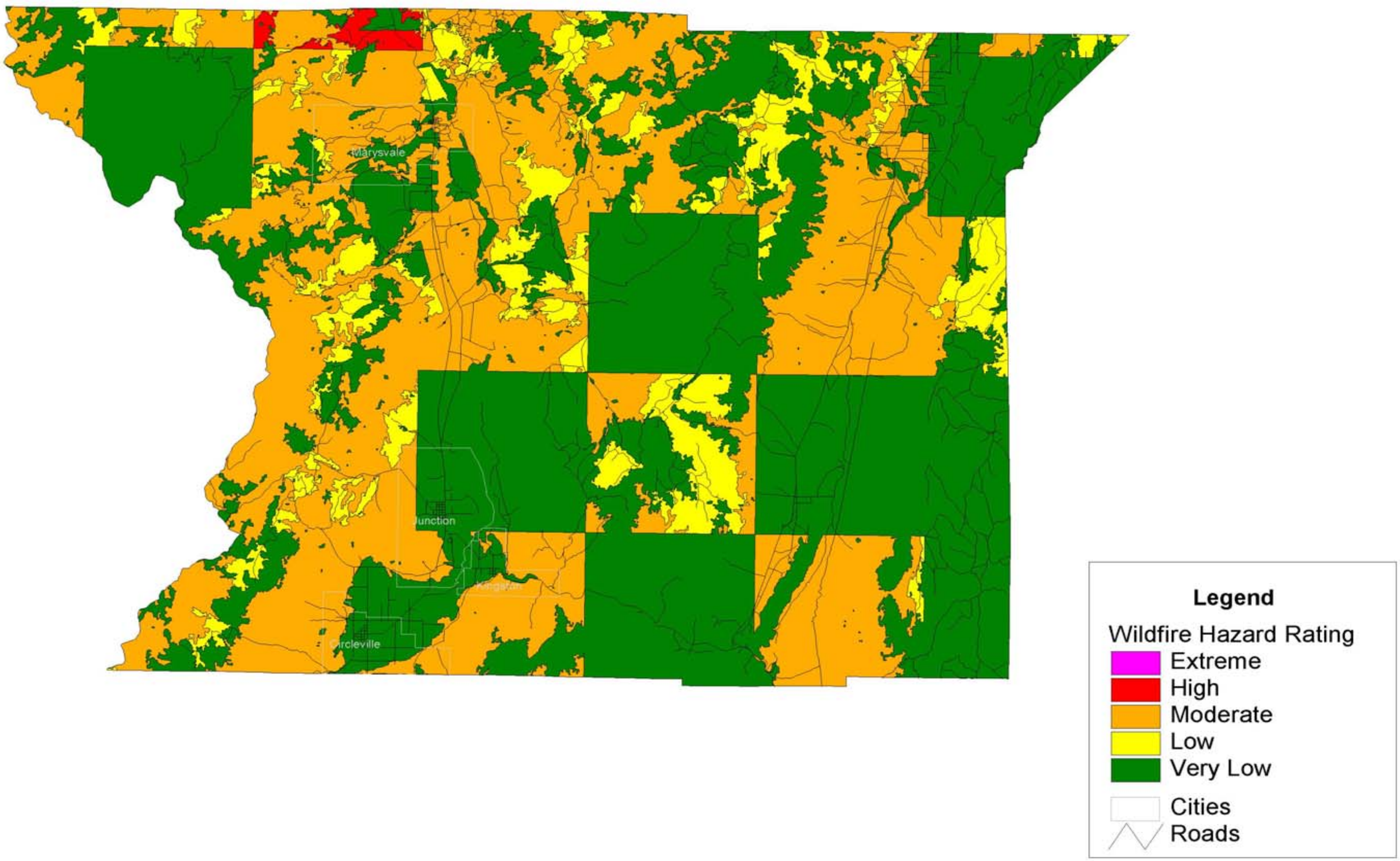
Millard County Wildfire Risk

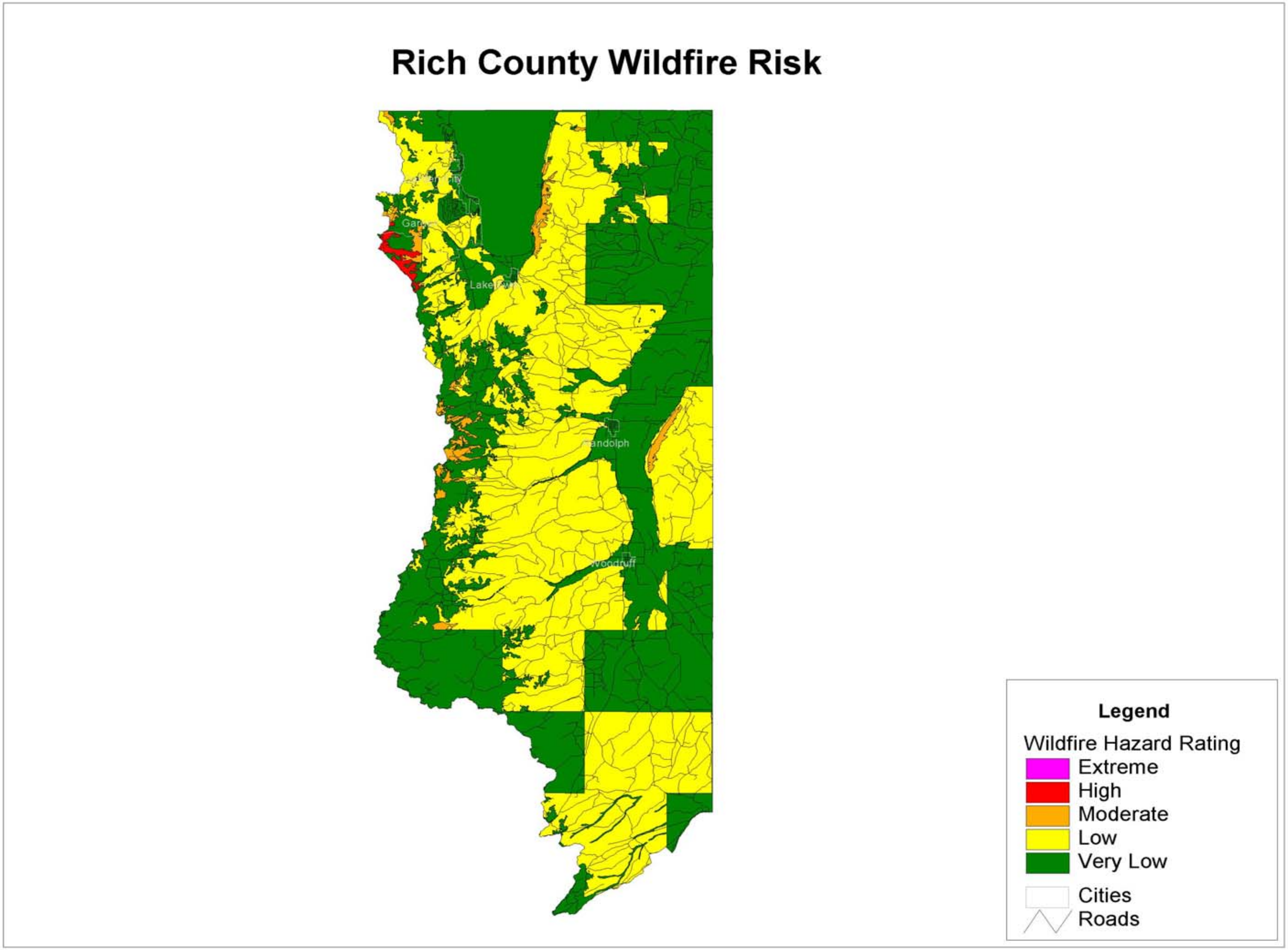


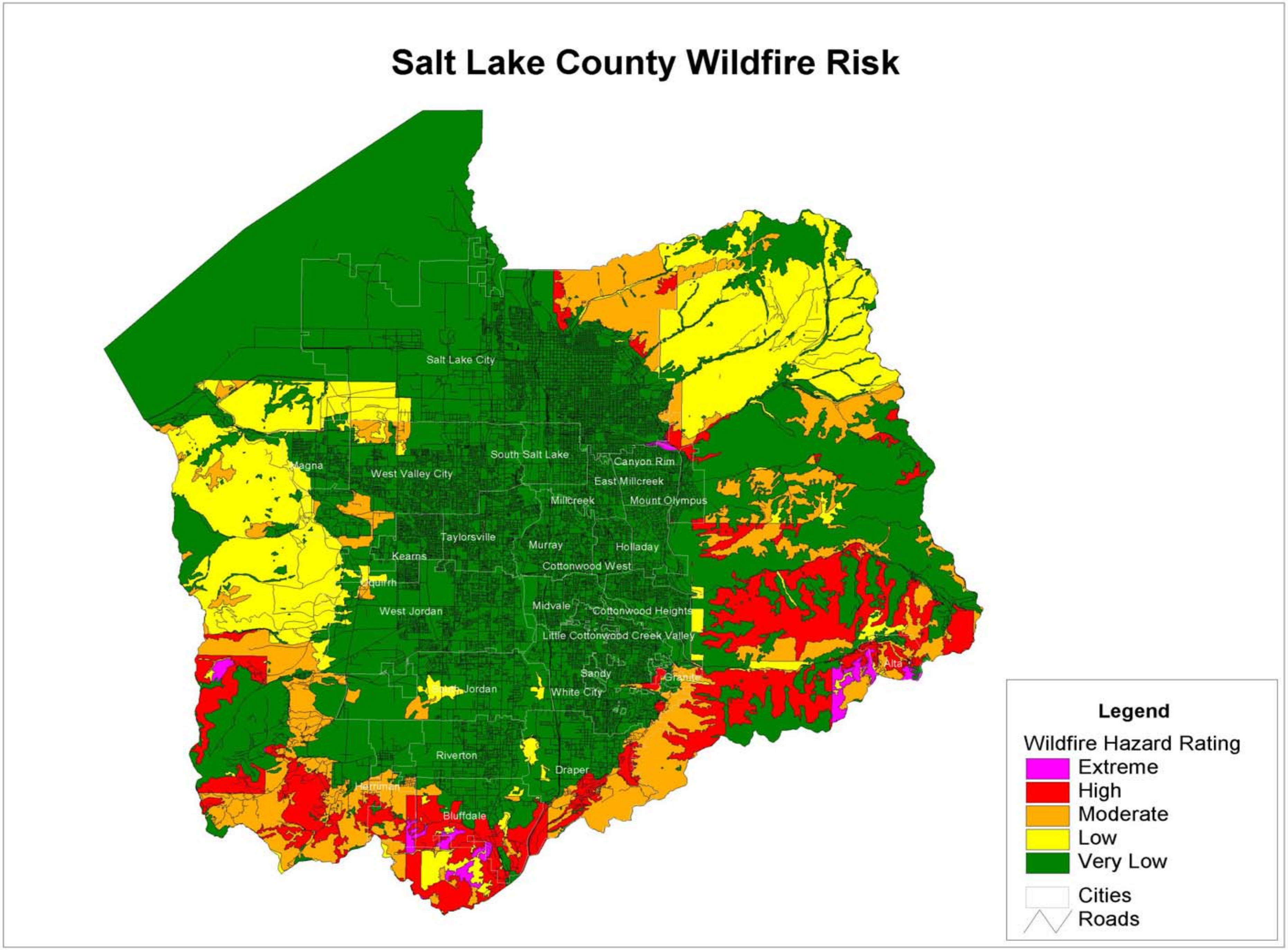
Morgan County Wildfire Risk



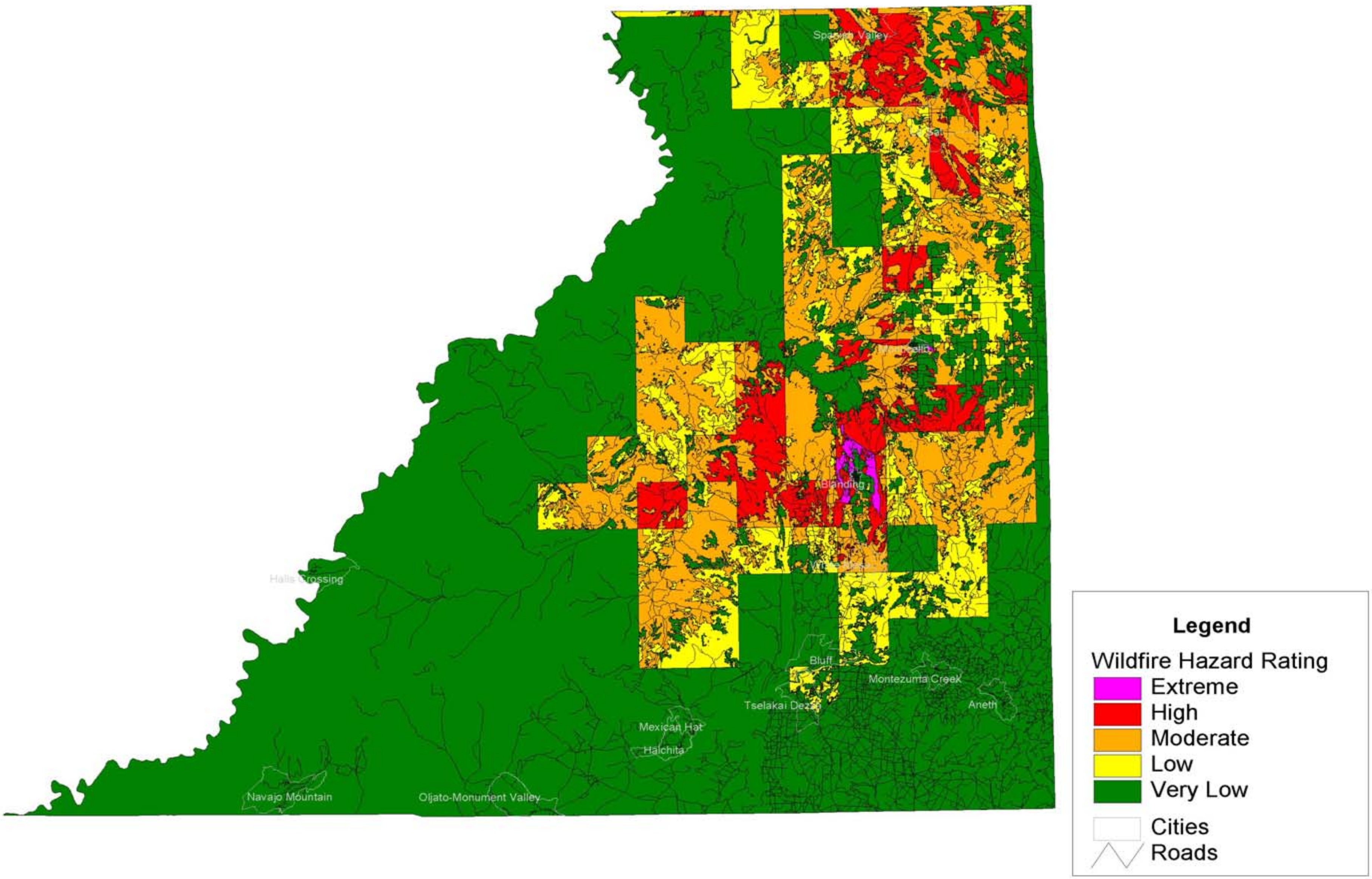
Piute County Wildfire Risk



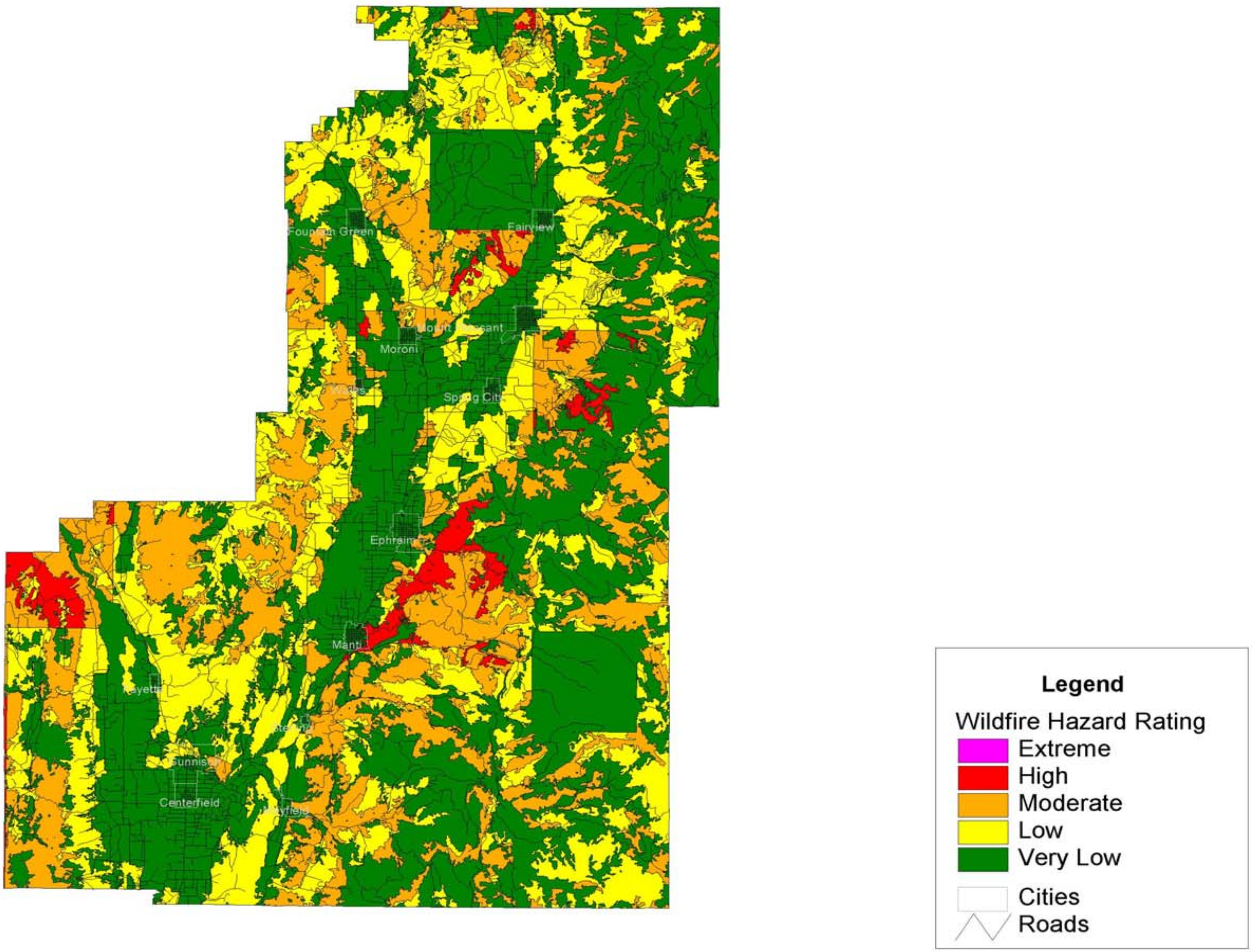

Rich County Wildfire Risk
Woodruff
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

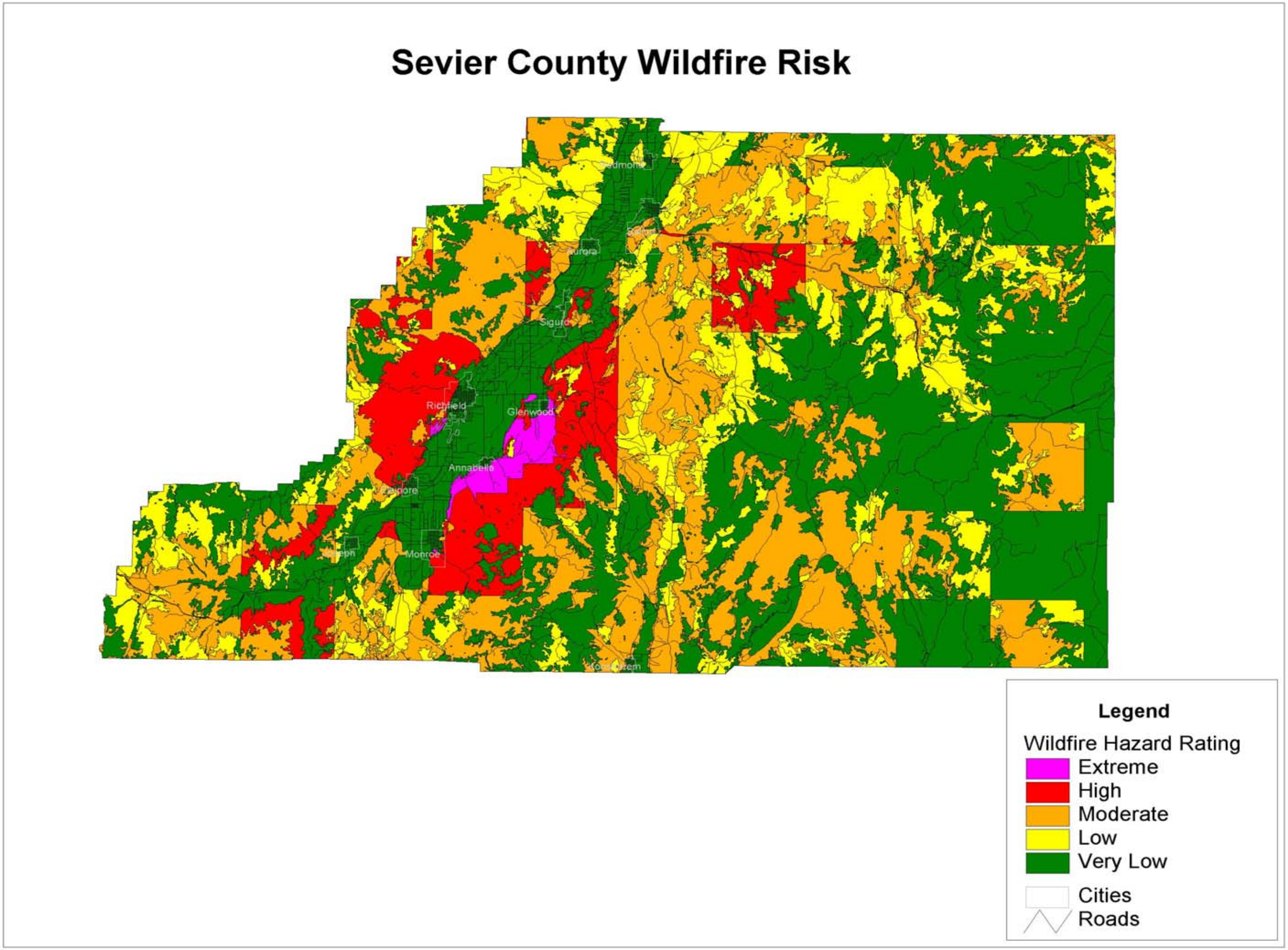

Salt Lake County Wildfire Risk
Salt Lake City
South Salt Lake
Magna
West Valley City
Canyon Rim
East Millcreek
Millcreek
Mount Olympus
Taylorsville
Kearns
Murray
Holladay
Cottonwood West
West Jordan
Midvale
Cottonwood Heights
Little Cottonwood Creek Valley
Sandy
Alta
Granite
South Jordan
White City
Riverton
Draper
Herriman
Bluffdale
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

San Juan County Wildfire Risk

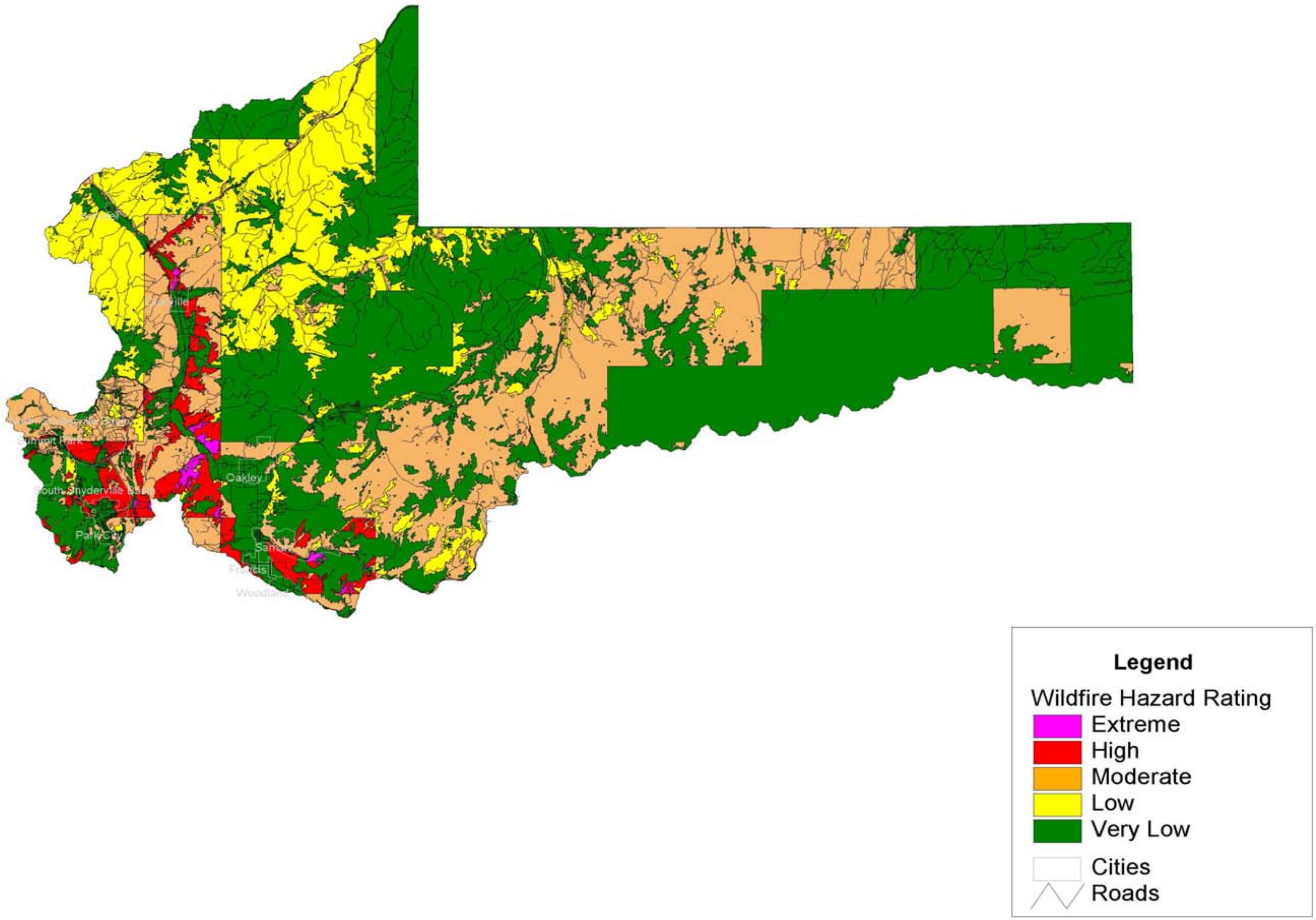


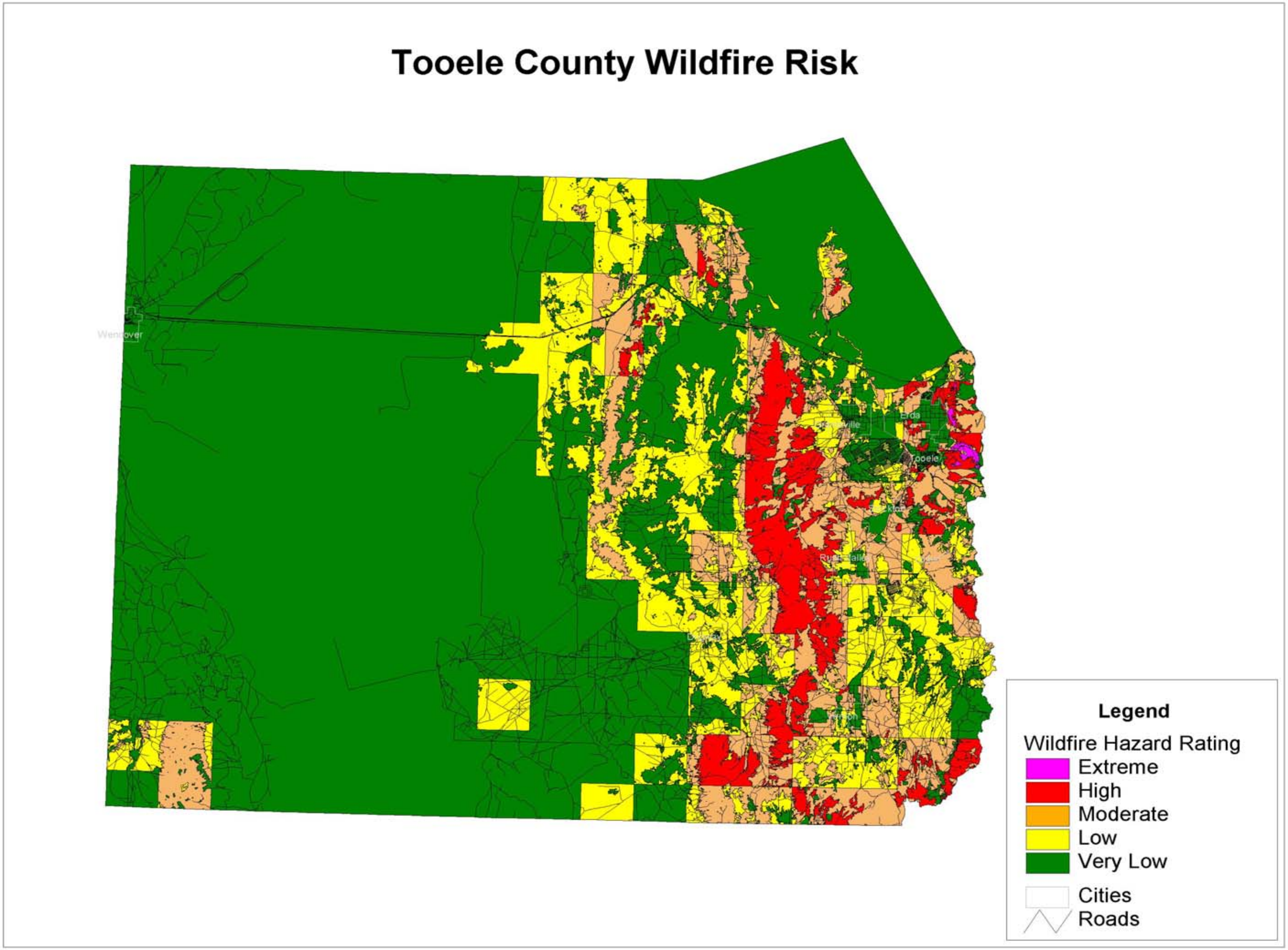
Sanpete County Wildfire Risk

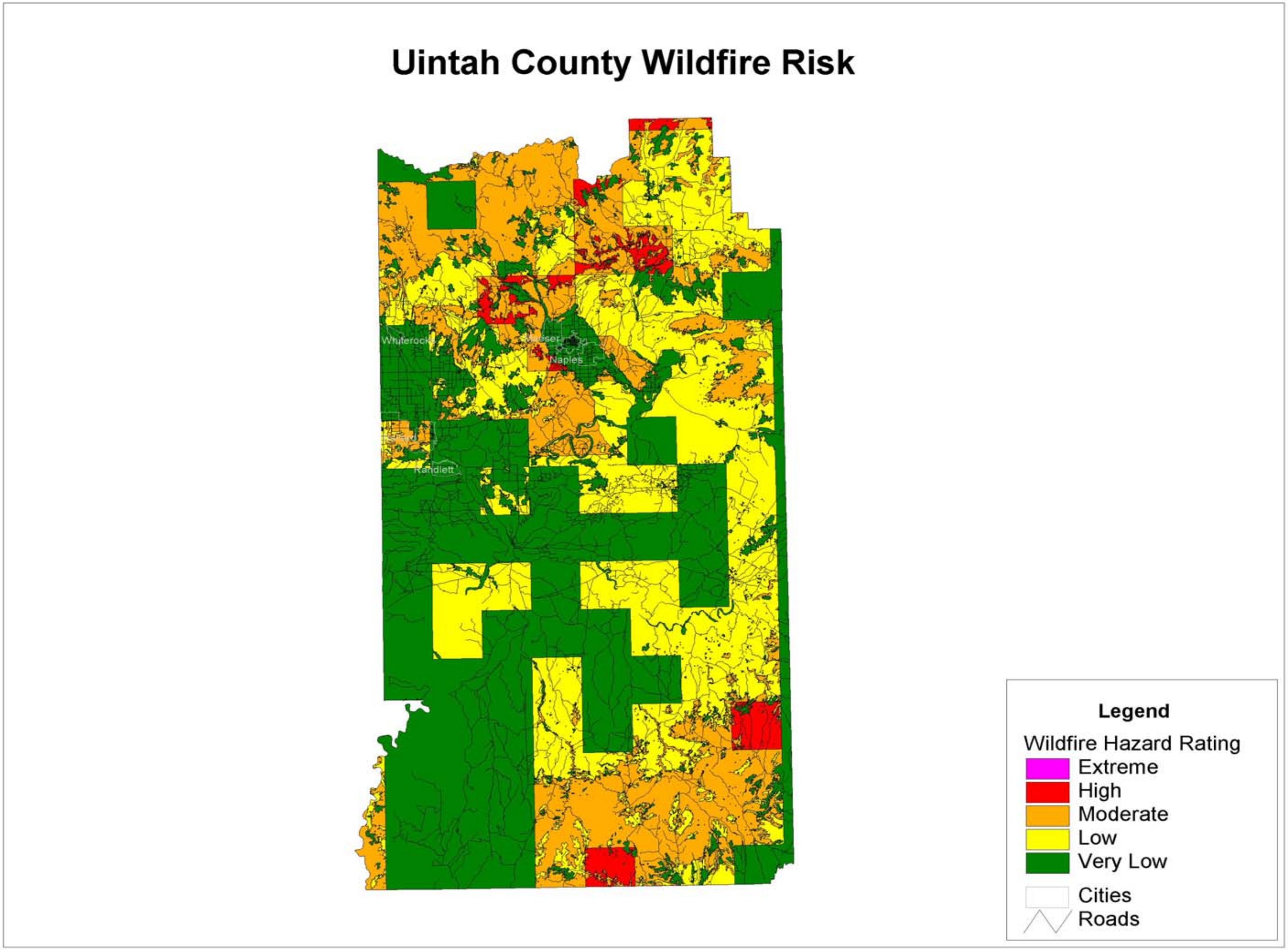


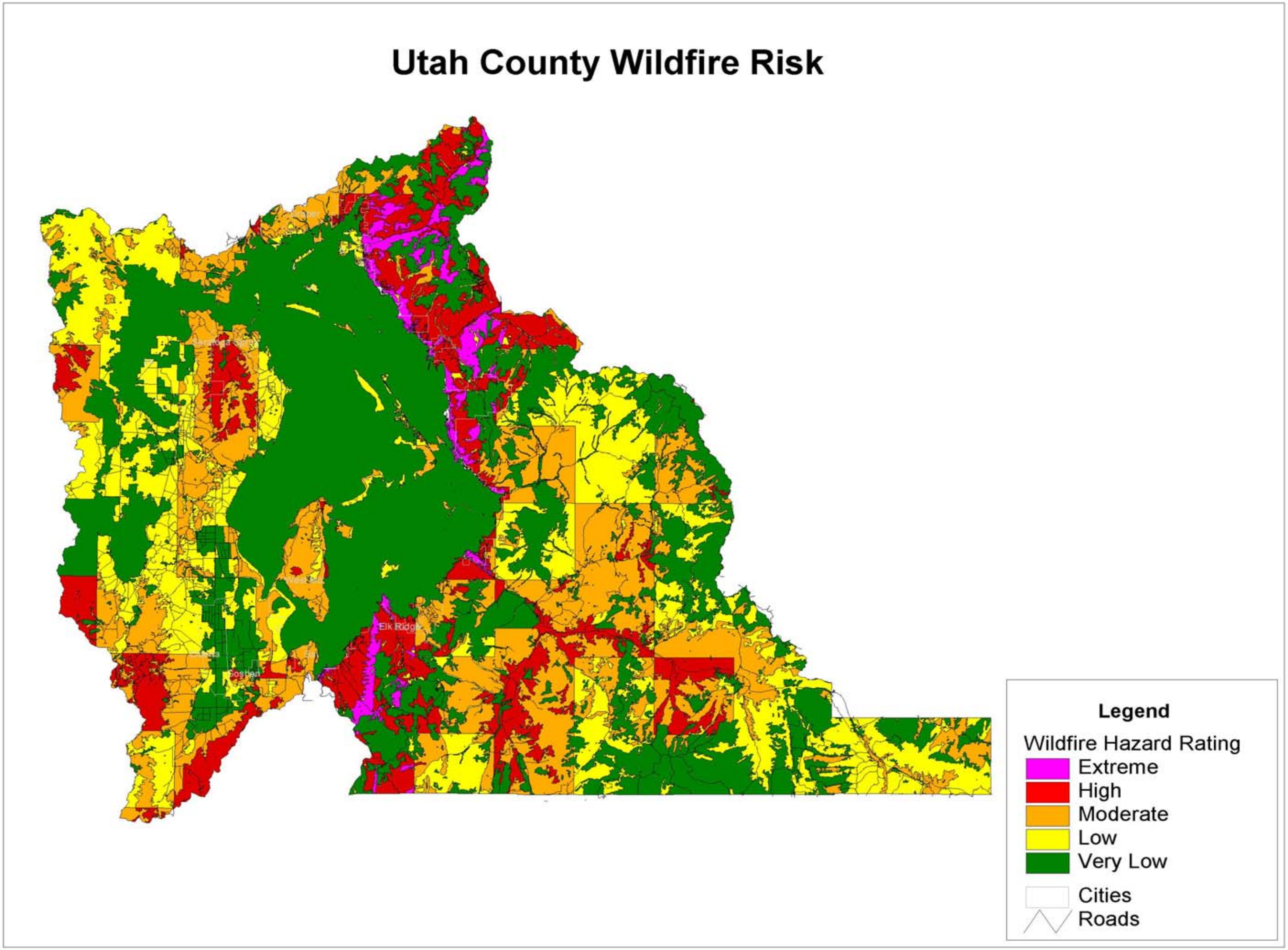

Sevier County Wildfire Risk
Aurora
Richfield
Glenwood
Annabella
Monroe
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

Summit County Wildfire Risk

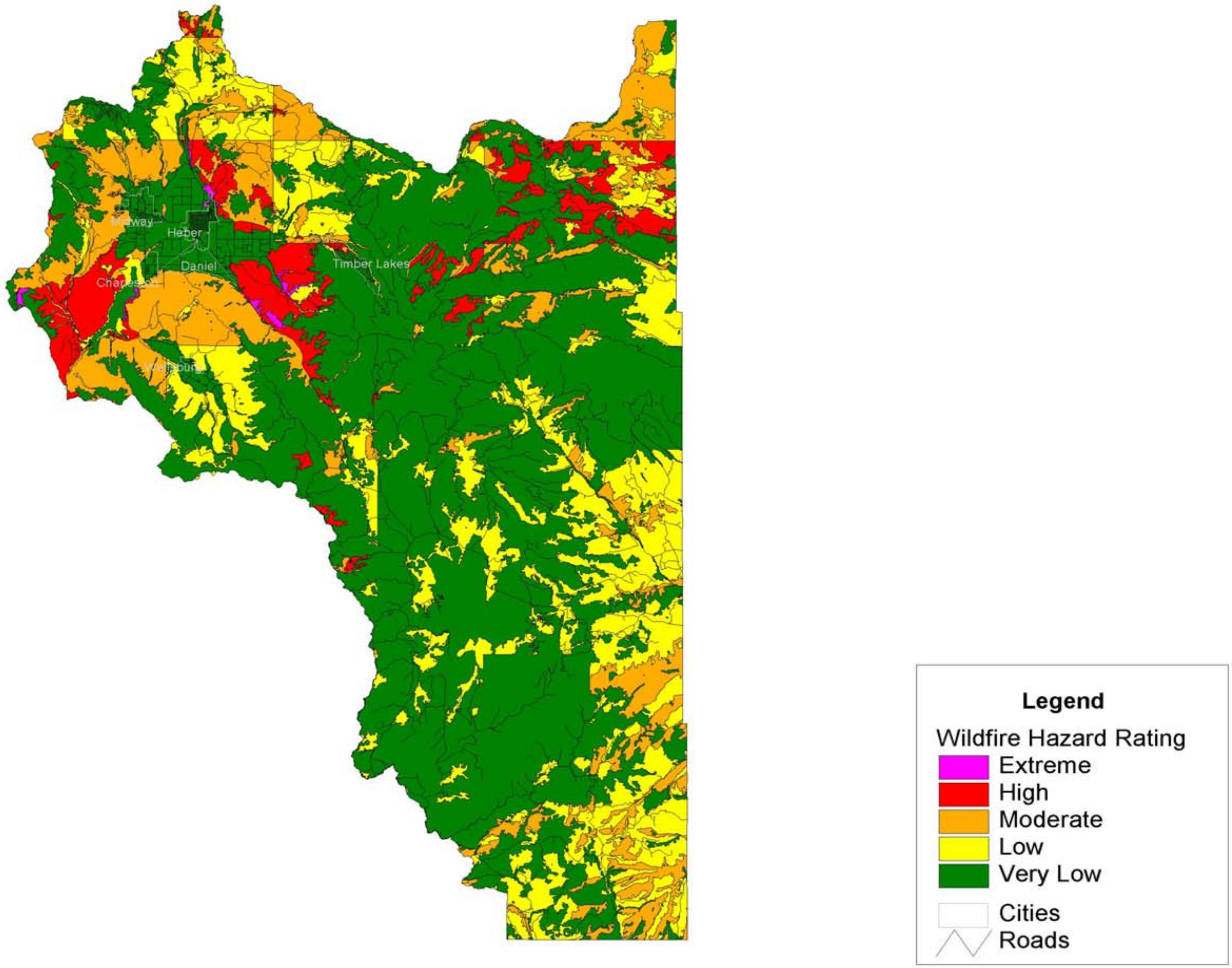



Tooele County Wildfire Risk
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

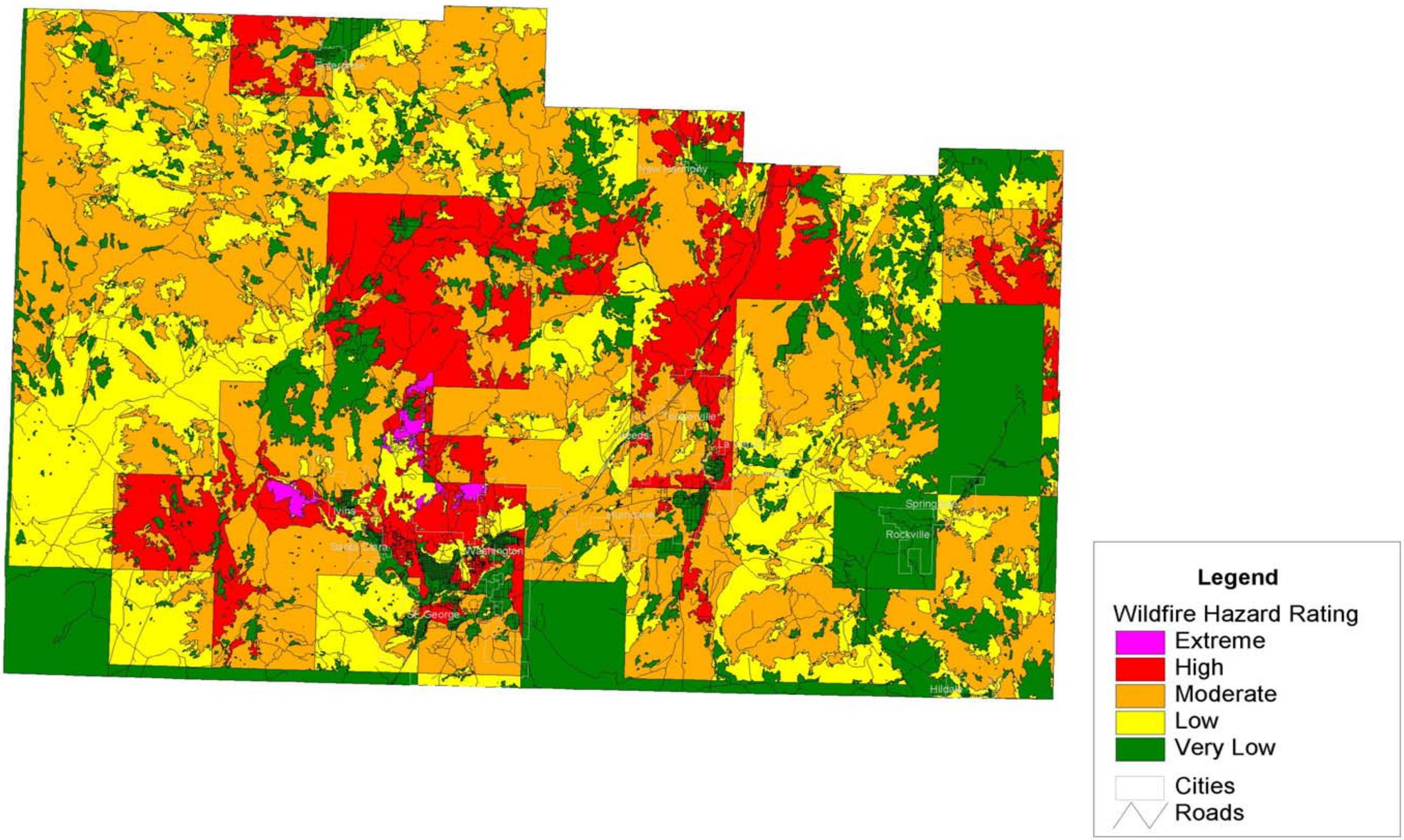

Uintah County Wildfire Risk
Whiterocks
Maeser
Naples
Randlett
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

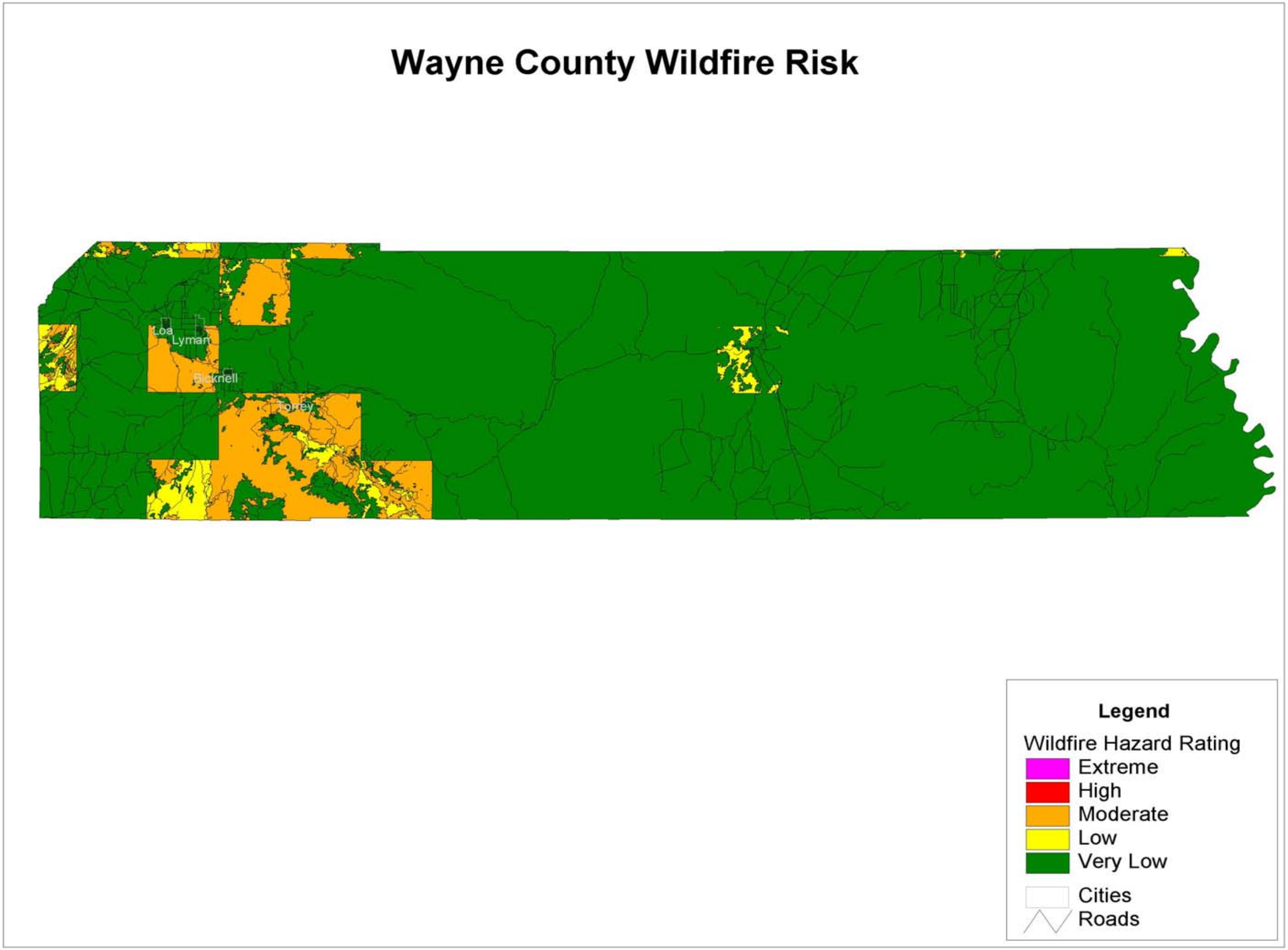

Utah County Wildfire Risk
Elk Ridge
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads

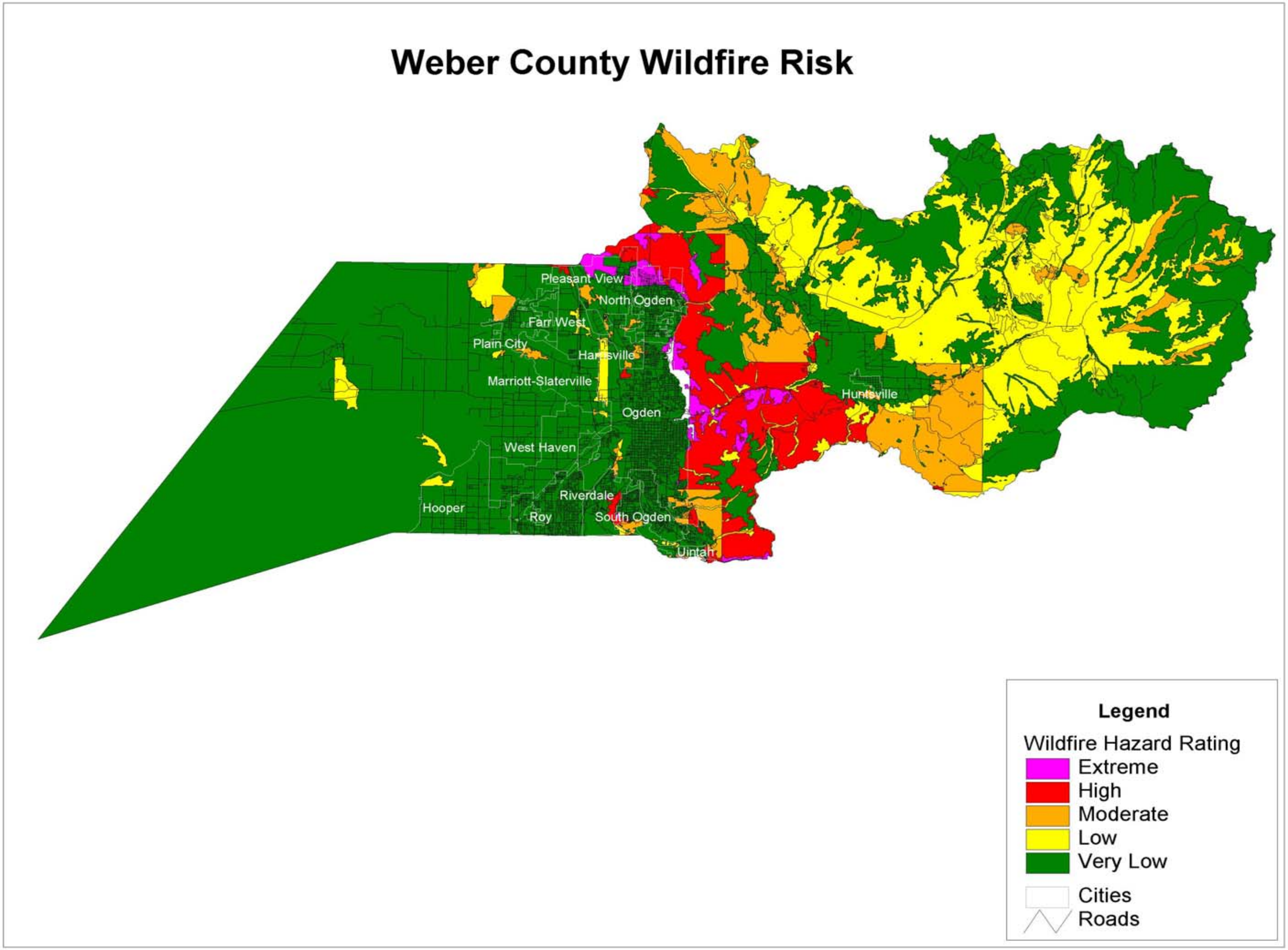
Wasatch County Wildfire Risk



Washington County Wildfire Risk




Wayne County Wildfire Risk
Loa
Lyman
Bicknell
Torrey
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads


Weber County Wildfire Risk
Pleasant View
North Ogden
Farr West
Plain City
Harrisville
Marriott-Slaterville
Ogden
Huntsville
West Haven
Riverdale
Hooper
Roy
South Ogden
Uintah
Legend
Wildfire Hazard Rating
Extreme
High
Moderate
Low
Very Low
Cities
Roads